Volume 48. March 1934. $4.00 a Year.
Number 1. Pages 1-122. $1.25 a Number.

# JOURNAL

OF THE

# New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY
THE NEW ENGLAND WATER WORKS ASSOCIATION,
714 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

Copyright, 1934, by the New England Water Works Association.

# OFFICERS

OF THE

# New England Water Works Association.

## 1933—1934.

PRESIDENT

E. SHERMAN CHASE, of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

VICE-PRESIDENTS

HOWARD M. KING, Superintendent, Water Department, Springfield, Mass.
(Term expires September, 1934)

ROGER W. ESTY, Superintendent of Water Works, Danvers, Mass.
(Term expires September, 1935)

DIRECTORS

HARRY U. FULLER, Engineer, Portland Water District, Portland, Me.
(Term expires September, 1934)

WARREN J. SCOTT, Director, Bureau of Sanitary Engineering, Connecticut State Department of Health, Hartford, Conn.
(Term expires September, 1935)

GEORGE A. SAMPSON, of Weston and Sampson, Consulting Engineers, Boston, Mass.
(Term Expires September, 1936)

PAST PRESIDENTS

(Members of Executive Committee)

GEORGE C. BREHM, Waltham, Mass.

RICHARD H. ELLIS, Water Commissioner, Newton, Mass.

SECRETARY

FRANK J. GIFFORD, Superintendent of Water Works, Dedham, Mass.

TREASURER

LELAND G. CARLTON, Water Registrar, Springfield, Mass.

EDITOR AND ADVERTISING AGENT

GORDON M. FAIR, Harvard University, Cambridge, Mass.

---

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 800 men. Its membership is divided into six classes, viz.:

*A Member* shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

*An Honorary Member* shall be a person of acknowledged eminence in some branch of water supply or of engineering.

*A Life Member* shall be a member whose service to the Association entitles him to special recognition by the Association.

*A Junior* shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

*An Associate* shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

*A Corporate Member* shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

| *Initiation Fees* | | *Annual Dues* | |
|---|---|---|---|
| Members | $ 3.00 | Members | $ 6.00 |
| Juniors | 1.00 | Juniors | 3.00 |
| Associates | 10.00 | Associates | 20.00 |
| Corporate Members | 10.00 | Corporate Members | 10.00 |

This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

MADE by your own local labor

— right IN your own community,

largely using YOUR own local

materials- so that your OWN money

remains in your own CITY.

Lock Joint Pipe Co., Ampere, N. J.
PRESSURE: SEWER: CULVERT: SUBAQUEOUS

**LOCK JOINT**
*Reinforced Concrete*
**PRESSURE PIPE**

# Table of Contents


PAGE

Portrait of President E. Sherman Chase ..... *Frontispiece*

A Ten Foot Parshall Measuring Flume at Providence.
By Chas. G. Richardson ..... 1

Modern Water Chlorination Practice. By L. H. Enslow ..... 6

Best Methods of Cutting Lined Pipe.
Superintendents' Discussion, lead by David A. Heffernan ..... 23

The Days of Small Things. By Charles W. Sherman ..... 26

Recent Additions to the Cambridge Water Supply.
By Howard M. Turner ..... 28

Corrosion of Brass in Water Subjected to pH Correction.
By Edward W. Moore ..... 47

A History of Water Service Installation in Newton.
By Michael J. Herlihy ..... 59

Water Works Practice at Taunton, Mass. By Arthur C. King ... 66

Results of Water Waste Survey in Lexington, Mass.
By A. A. Ross ..... 72

A Resumé of Changes in Practice and Recent Improvements in Water Supply at Newton, Mass. By Richard H. Ellis ..... 76

Engineering Problems Connected with Recent Improvements to the Newton, Mass., Water Supplying Works.
By George A. Sampson ..... 88

The Boiler Plant at the Needham Street Pumping Station, Newton, Mass. By David Eames ..... 102

Experiments on the Newton Water and Treatments for the Control of Corrosion. By F. Wellington Gilcreas ..... 105

Proceedings:
December Meeting ..... 117
January Meeting ..... 118
February Meeting ..... 118

Obituary:
Albert Livingstone Sawyer ..... 120
Sir Alexander Houston ..... 121
Floyd A. Nagler ..... 122

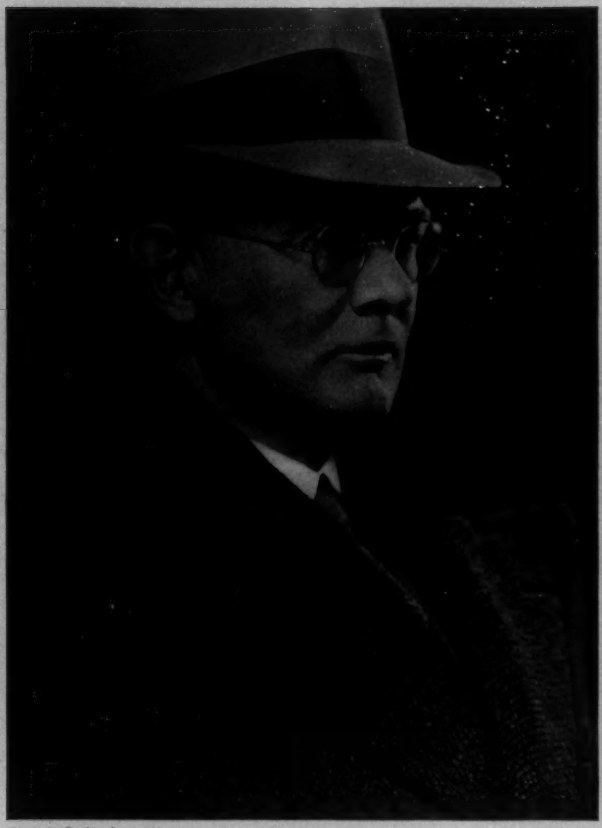


Photo by Bachrach

E. SHERMAN CHASE

President of the New England Water Works Association
1933-1934

# New England Water Works Association

ORGANIZED 1882.

Vol. XLVIII. March, 1934. No. 1.


*This Association, as a body, is not responsible for the statements or opinions of any of its members.*

## A TEN FOOT PARSHALL MEASURING FLUME AT PROVIDENCE.

BY CHAS. G. RICHARDSON.*

[*Read September 20, 1933.*]

While this paper relates to a particular sewage-metering problem the methods used in its solution are equally applicable for water under similar conditions and requirements.

For the last two years the Providence Sewage Disposal Plant at Fields Point has been undergoing gradual but major changes in anticipation

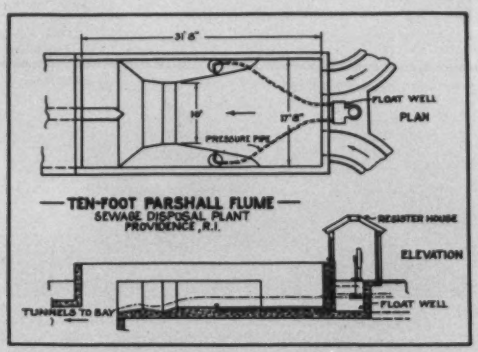



FIG. 1.— PLAN AND ELEVATION OF PARSHALL FLUME, PROVIDENCE, R. I.

of the day when it will emerge from chemical precipitation, begun in 1901, to the activated sludge process. Sewage from the entire Providence area arrives at the Ernest Street Pumping Station near the plant where it is lifted 27 ft. to the influent channel. After passing through various settling and clarifying tanks the effluent is discharged through large underground tunnels into Narragansett Bay 400 ft. distant.

* Builders Iron Foundry, Providence, R. I.

If the plant is to be operated efficiently and satisfactory treatment obtained, it is essential to measure the entire flow and record its hourly variations. At first it was proposed to install an ordinary weir in either the influent or effluent channel, but calculation revealed that in times of heavy storms or high tides the resulting backing up of the sewage might overflow

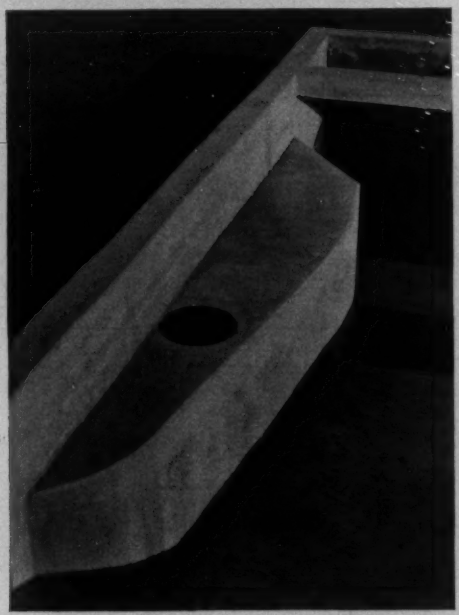


FIG. 2.— SIDE VIEW OF PARSHALL FLUME, PROVIDENCE, R. I.

screen chambers, manholes or process tanks. A large Venturi tube was considered but would have involved costly excavation due to the hydraulic gradient characteristics. Finally a Parshall Flume was suggested.

Since this device is little known in New England, brief mention of its development and characteristics may not be inappropriate. In 1915, V. M. Cone, curiously harmonizing his scientific investigations with his name, conducted experiments at the Colorado Agricultural College, Fort Collins, Col., upon an open, Venturi-shaped flume having a converging inlet, straight throat and diverging outlet, with level floor. In 1917 he published his results, which seemed to be promising. Other experimenters and hy-

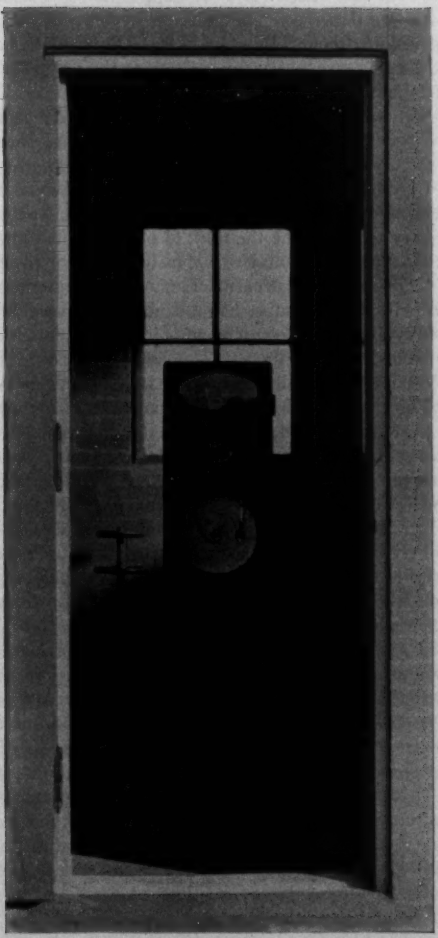


FIG. 3.— REGISTERING DEVICE FOR PARSHALL FLUME, PROVIDENCE, R. I.

draulic laboratories, notably the Cornell Laboratory, pursued the idea but gradually lost their enthusiasm. It seemed impossible to establish a definite, dependable relation between the difference in head at inlet and throat and various rates of flow through the flume. R. L. Parshall, Senior Irrigation Engineer, however, continued experimenting at the Colorado Station and after literally thousands of calibrations devised many important changes, including alterations in the angles of convergence and divergence and in the side slopes to give greater stability of the water surface. He also added a dip in the floor beyond the throat section to produce a hydraulic jump at this point. Of these changes the last was the most important since it reduces observing two gage heights (inlet and throat), which were previously necessary to determine the flow, to observing a single gage height in the inlet cone for the great majority of installations. While he called the new device "The Improved Venturi Flume," the American Society of Civil Engineers in 1930 announced that a new principle in flow measurement had been evolved and in compliment to its originator officially changed the name to "The Parshall Flume." This device has now come into wide use in the West in irrigation districts, where such flumes are installed with throat widths of 1 to 40 ft., and in corresponding maximum capacities of 0.5 to 2 600 cu. ft. per second, or approximately 0.3 to 1 700 m.g.d. The measuring range for "free flow" discharge, *i. e.* using the single gage heights, averages about 15 to 1. An important characteristic also is the relatively low loss of head, about one quarter that of the usual weir.

At the Providence plant, an open concrete chamber had been constructed to receive the flow from the two main effluent channels just preceding entrance to the tunnels leading to the Bay. In this chamber it was decided to construct a Parshall Flume to be suitable for a future possible flow rate of 120 m.g.d. The throat width adopted was 10 ft., and correct proportions for the Flume dimensions were strictly followed. While the Parshall Flume is said to be largely independent of approach conditions it was realized that the curved entrance of the two influent channels would result in considerable turbulence, and it was decided to take off two pressures, one from each side of the entrance cone at the specified location to produce an average height in the common float well. Brass pipes, 2½-in. in diameter, separately valved, lead from these vents to the float well of the recording instrument. An excellent, smooth job of reinforced concrete work was done in constructing the Flume. At the sill of the throat, where the velocity is highest, a section of steel rail was embedded. Manholes were located over the pressure-valve connections at the opposite sides of the inlet cone, and suitable connections were provided for back-flushing the pressure pipes. The Flume itself, due to its velocity-accelerating characteristics, is "self-scouring."

For the recording instrument a Builders Iron Foundry Type Y Register-Indicator-Recorder, specially modified, was used. It is housed in a neat building of selected faced brick, having floor dimensions 6 ft. 7 in.

by 4 ft. 2 in. at the head of the flume chamber. This instrument is operated by a 24-in. diameter float in a concrete well immediately beneath the house, the well being connected, as stated, to the two flume vents. The connection between float and register is a flat monel ribbon, properly counterweighted, and perforated to fit over pins in the register-actuating pulley. There are the usual three dials: rate indicating, rate recording and totalizing. The range of graduation is from 10 to 130 m.g.d.; the corresponding float travel is from 0.5 to 2.7 ft. The curve of this relation is quite flat. An additional feature is a Selsyn motor transmitting-attachment which actuates a secondary rate-indicating dial located in a basement window of the distant Chemical Laboratory, convenient for regular observation by the plant operators.

The Providence Parshall Flume has now been in continual and satisfactory operation for eight months. Acknowledgment should be made to Julius W. Bugbee, chemist in charge, for many details of design, and to Messrs. Waterman, Nolan and Kendrick of the Public Works Department for helpful coöperation. In a sense the installation represents engineering work of a pioneering nature, since no flume of this type approaching it in size has been heretofore utilized for measuring sewage. The Flume has shown itself to be sensitively responsive to small changes in rate of flow. The variation in flow thus far recorded is from 5 to 120 m.g.d., the latter occurring recently during a heavy storm. At extreme high rates it has been noted that the turbulence in the converging section is materially less than at a 50-m.g.d. rate.

Mr. Parshall, in expressing his great interest in the installation, remarks that while it would seem that the flow is very much disturbed, he yet feels certain that any resulting inaccuracy "would be well within 5 per cent." While the recorded rates since installation have been entirely consistent with rates obtained from carefully kept weir records under similar conditions in previous years, it has not been possible, until very lately, to make comparisons with other measuring devices, such as weirs and current meters. All of these have indicated accurate Flume performance. During the week of September 11, Mr. Bugbee, by altering the course of the sewage through certain channels, was able to get a direct comparison with a 10-ft. standard weir, and he reports the following gratifying results:

| Date of Test | Duration of Test | Average Flow m.g.d. | | Percentage Difference |
|---|---|---|---|---|
| | | Flume | Weir | |
| Sept. 13 | 9:45 A.M. to 12:45 P.M. | 48.00 | 47.91 | 0.19 |
| Sept. 13 | 12:45 P.M. to 1:45 P.M. | 23.00 | 22.94 | 0.26 |

It will be noted that agreement is within approximately ¼ per cent.

Apparently the Parshall Flume should become increasingly useful for the measurement of water and sewage in open channels.

# MODERN WATER CHLORINATION PRACTICE.

L. H. ENSLOW.*

[*Read September* 21, 1933.]

Chlorination of potable water supply dates back to 1908 in America but was practiced successfully as early as 1902 in Belgium. For a long time considered, in conjunction with filtration, as being the line of last defense only, chlorination is now an acknowledged integral part of the complete process — and an increasingly important part.

Interestingly enough, in early chlorine applications in conjunction with filtration the chlorine was applied prior to filtration, only to be changed to the filtered water. In numerous instances, it has now been returned to the raw water, or the coagulated water, to produce desired effects in filtration practice other than mere disinfection.

Although chlorination of water had become fairly widely established in America by 1915 it was not until 1918 or 1919 that chlorination was placed on a basis subject to prompt and simplified control. I refer to the practical application of the orthotolidin test in the control of chlorine dosages so as to insure the presence of residual chlorine in the treated water under all conditions — thereby insuring adequacy of disinfection without over chlorination — an accomplishment which previously could only be assured through tedious bacteriological examinations, requiring several days for completing the test. Such time-requiring control technic frequently had proved inadequate for continuous protection. Chlorination having been placed on a dependable basis by employing this simplified control method, the process gained markedly in favor because of its greater dependability and reduced likelihood of over-chlorination resulting in inevitable taste complaints.

## Combating Taste Troubles.

When dealing with fairly pure waters the taste problem was solved by resorting to the use of this new and handy index of chlorination efficiency. But to make matters interesting to the water purification man, along came the problem of taste production which was traced to the reactions between chlorine and foreign matter in the water — in many instances associated with human or industrial pollution or pipe coatings, but in others created by natural conditions, notably the presence of decayed vegetation and disintegrating algae.

*Super and Dechlorination.* To combat such disturbing conditions it became necessary to open up a new bag of tricks in chlorination practice

*Editor, "Water Works and Sewerage" and Sanitary Engineer, The Chlorine Institute, New York City.

which included the introduction of super-chlorination to destroy, by oxidation, the offending materials and thereafter employing dechlorination to obviate chlorinous tastes due to the excess chlorine added. This procedure has been effective but somewhat expensive.

*Permanganate Treatment.* The application of permanganates in conjunction with ordinary chlorination was a cure in many instances and continues to be effective in dealing with certain conditions wherein algae and decayed organic matter have been responsible for the production of color, tastes, odors, hydrogen sulphide and ferrous iron or manganous manganese. Naturally, permanganates are most satisfactorily applied to the water prior to filtration. This treatment is most effective when used in combination with prechlorination which insures removal of the objectionable manganese during the coagulation and filtration process. One should not overlook the value of permanganates in solving future problems. Even though other newer processes appear to have a greater appeal on the whole there are situations in which permanganate treatment in conjunction with prechlorination has distinctive advantages as an oxidizing process.

*Prechlorination.* Repeated warnings that prechlorination would destroy the efficiency of the bacteria removing "Schmutzdecke" of the filter beds were disregarded by a few hardy operators who were of the opinion that a stiff application of so powerful an agent as chlorine might be effective in keeping down obnoxious growths and putrefaction in the basins and filters and serve moreover as an oxidizing agent to destroy many of the end products of decay or the essential oils already present in the raw water. Half hearted attempts in this direction frequently failed. But they, who in the words of Sir Alexander Houston, showed "chlorine boldness" in place of "chlorine temerity", were successful for the most part; if not immediately then eventually so. The process in reality amounted to moderate super-chlorination and gradual dechlorination through progressive conversion of much of the residual chlorine into nascent oxygen, the remaining excess being removed during passage through the filter beds. In addition to taste improvement it was apparent to many that other technical and also economic advantages, such as improved coagulation, reduced filter bed troubles, lessened wash water requirements and decreased putrefaction of sludge in the basins, were being realized. The move toward heavy prechlorination was decidedly in the correct direction and has lead recently to the return in several instances to heavy chlorination of the raw water and discontinuance of pre-ammoniation. Because ammoniation slows down the oxidizing action of chlorine and thereby its destructive action on organic impurities—including those responsible for objectionable tastes—as well as for other reasons, ammonia may be more effectively applied to the filtered water.

For the work of taste *destruction*, raw water chlorination preceded or followed by applications of activated carbon is preëminently the most uni-

versally successful procedure. More will be said later about this process and the efficacy of post-ammoniation.

The addition of ammonia to raw waters ahead of chlorination has been in several instances an effective taste-prevention procedure but care in manipulation is required, and the practicability of the process in comparison with postammoniation is to be questioned.

*Postammoniation.* Ammoniation was first practiced for taste prevention by Houston in England and later by McAnnis at Greenville, Tenn., in 1926 where the process proved, according to the latter, to have been effective and "as simple as rolling off a log." From this beginning the use of ammoniation in conjunction with chlorination has grown until there are now 650 installations of ammoniation equipment in America.

At Greenville it was a case of preventing chlorinous tastes and more especially tastes which residual chlorine produced when coming in contact with the lining of the mains or the painted interior walls of the standpipe. To many the process was equally as simple as at Greenville, but to others it was somewhat disappointing, although the chlorine required to maintain a definite residual chlorine value in the treated water could be and was reduced in practically every instance. The reason for this was readily explainable. The chlorine fixed as one or the other of the two chloramines (principally dichloramine in waters of less than pH 7 and almost wholly mono-chloramine in waters with as high as pH 8) had a much lowered oxidation potential. Hence it did not attack and combine with reducing organic products as rapidly or as pronouncedly as did the more powerful chlorine or the hypochlorous acid which chlorine produces. Neither did chloramine-chlorine attack the living organisms as vigorously. This constituted its one weakness.

The chloramines, being mild compounds, did not impart a chlorinous taste to very pure waters nor did they combine with foreign bodies to produce tastes in less pure waters. It merely became a matter of securing the most efficient distribution of the ammonia prior to an efficient and thorough distribution of the chlorine to demonstrate the true value of the process and to produce maximum economies. We have long since learned that the more perfect the distribution of these two chemicals the less the quantities of chemicals required. This is particularly of major importance in reducing to a minimum the requirement of the more expensive ammonia. Modern practice involves the use of lower and lower ratios of ammonia to chlorine. Prior to an understanding of the importance of distribution and mixing, ratios of 1 ammonia to 2 chlorine, or even higher, were employed — whereas, now, in postammoniation practice (ammonia added after filtration but prior to final chlorination) the ratio of 1 ammonia to 4 chlorine proves to be ample in most instances, and even lower ratios are effective in many cases.

The required ammonia-chlorine ratio is a fixed quantity for any fixed condition. It is decidedly variable however with varying pH values of

waters, and if we assume the pH value to be adjusted to a constant point, as is done in modern corrosion control, then the quantity of ammonia to be added will be governed by the *available* ammonia content originally present in the water treated. In other words there is a definite minimum of ammonia needed to produce chloramines from a given weight of chlorine. If there already is some ammonia present in the water, it becomes necessary to make up only the deficiency. It may not be out of order then to suggest the application of lime in pH adjustment prior to postchlorination or along with the chlorine via a common hose line. In doing so it becomes necessary, however, to recall that in waters adjusted to pH 8 or higher the reaction velocity of the monochloramine produced is materially slower than that of dichloramine. Thus the contact period required for efficient bacterial destruction must be increased unless prechlorination has been employed. If prechlorination, producing maximum safety, has been employed, the major value of the ammonia-chlorine post treatment becomes that of precluding tastes and insuring the several advantages of sterile conditions in mains, reservoirs, dead ends and a safeguard against chance pollution from unforeseen causes, including leaky cross-connections.

Returning to the matter of the mild behavior of chloramine chlorine it has been learned, as was to be expected, that chlorine in this form created a saving in the amount of chlorine necessary to secure the same residual chlorine value found effective before beginning ammoniation. It was not appreciated until later, however, that the milder form of chlorine being a less efficient bactericide a high concentration would be required in safe practice, unless the water had already been effectively prechlorinated. That an increased contact period was necessary, was generally appreciated. On the other hand, the considerably slower bacterial attack at pH values above 7.8 and at temperatures under 10° C. was not accorded sufficient recognition until studies made by Gerstein in the Water Control Division of Chicago and by Holwerda in Holland revealed the importance of these two factors.

In discussing the Chicago report in 1931, the writer felt it necessary to sound a note of warning to operators of chlorinating plants employing ammonia and saving chlorine by maintaining no higher residuals than had been found requisite without ammoniation. Subsequently this warning has been proved a justifiable one—one to the effect that a new and lesser weight must be given to residual chloramine chlorine values. Further, that it would be found that higher residuals would be required in many instances. How much higher, would be determined by such factors as temperature, alkalinity and the available period of contact. It can now be stated with fair assurance that about double the residual to produce former efficiencies with ordinary chlorination (after 10 minutes of contact) will be required when changing over to the ammonia-chlorine treatment. That 20 minutes of contact and preferably a longer period should be anticipated as the minimum safe requirement. With waters as alkaline as pH 8.0 and higher, there is a hazard in making any sort of rule with reference to safe practice

in cold weather. In every instance the operator should determine safe practice for the conditions in hand. It is fortunate that much higher residuals may be carried without complaint from taste. This makes it possible to start at high figures and drop the dosage gradually to a point where further lowering will constitute doubtful safe practice. This rule applies equally in the control of swimming pool chlorination as in that of potable water.

## Modern Ammoniation.

In modern practice, ammoniation is being employed to do two major things: (*a*) to prevent chlorine tastes created by over-chlorination and (*b*) to create a persistent form of available residual chlorine which is of pronounced value in the distribution system.

Concerning the latter, I refer to the fact that the presence of the chloramine keeps down dead end complaints (red water or black water) and reduces the necessity of frequent flushing of mains. It controls growths of *crenothryx* and the like in the mains and suppresses biologically created tuberculation in long mains or in distant fringes of the distribution pipe system. It prevents putrefaction of pipe slime carried to the dead ends, the latter being a breeding ground for acid-producing organisms that sap the oxygen from the surrounding water and cause the production of foul odors, including hydrogen sulphide, and vile tastes, including phenolic substances in dead-end water, not to mention high carbon dioxide and iron content due to corrosion. It is a fortunate water-works superintendent who does not receive numerous summer complaints from consumers on dead ends or who has not tasted of the iodoform water at such points when chlorine alone has been used and the residual chlorine in the fresh (new) water mingles with the foul water stagnating in low-velocity sections of the system.

To those in charge of unfiltered supplies which are subjected to variable flow or pumping rate or variable composition of the water, or both, wherein the water flows directly to the system or reservoir floating on the line, the ammoniation process has been a great boon. The careful control of chlorine dosage in such cases has become of secondary importance. The upper limits of non-taste-producing residual in the form of chloramine are sufficiently high to permit setting the minimum chlorine requirement frequently for maximum rates of draught without having the maximum residual at minimum draught or flow exceed that permissible. The early morning "chlorine cocktail" is a rare beverage in the consumer's home served with water treated by the ammonia-chlorine process which is accorded some semblance of supervision.

Referring now to the weakness of the process, *i.e.* the longer contact period required or the higher residuals requisite with shorter or longer contact, the process can be reversed to procure the previously outlined advantages, when applied to waters which do not produce tastes other than

those of chlorine, *i.e.* no chloro-byproduct tastes. If the available contact period is short between the points of chlorination and consumption, it may be more feasible to insure rapid disinfection by adding the chlorine first and applying the ammonia thereafter to convert the residual chlorine to chloramine. In other words, add sufficient chlorine to leave 0.2 to 0.4 p.p.m. residual after a 10 minute or longer contact and then apply ammonia and simultaneously the alkali, if such is used to raise the pH value to control corrosion. One interesting feature of this reversed procedure is the reduction in ammonia requirement. Only sufficient ammonia is needed to combine with the residual chlorine and not an amount required to satisfy the entire chlorine dosage in accordance with usual practice. Economically and hygenically such a procedure has its distinctive appeal where practical.

### Activated Carbon and Prechlorination.

By all odds the most modern and reliable practice in taste control involves the use of powdered activated carbon in conjunction with prechlorination or without it. From all that can be learned by observation, however, a combination of prechlorination and carbon treatment produces results superior to those obtained by the use of either alone. Depending upon the desired accomplishments, the carbon is applied to the raw water along with or ahead of the chlorine or it is applied to the coagulated settled water just ahead of the filters. The best practice under variable conditions is subject matter for a paper in itself. For assisting coagulation and suppressing sludge putrefaction in addition to taste removal, or where short-period coagulation basins are involved, it seems sufficient and preferable to apply carbon to the raw water. If the water is turbid or the coagulation basins large, no carbon is added to the raw water, only to the clarified water. There are intermediate conditions wherein application at one point at one time and at another or both points at other times is apparently best practice.

The great value of carbon is its ability to remove colloids from the water. This means actually increased purification of the water and with it taste *removal*, in distinction to taste prevention. Indicative of the actual adsorption and removal of chlorine-demanding substances from the water is the observation that water (raw or settled) when treated with powdered carbon prior to chlorination has its chlorine-demand value reduced—sometimes appreciably so. There is evidence to the effect that a small quantity of powdered carbon added to the raw water improves coagulation. Interestingly enough in such high dilution the carbon does not dechlorinate the water. To the contrary, in combination with carbon, the residual chlorine after passage through the basins becomes more pronounced, but when powdered carbon is laid down on the sand filter bed it completely declorinates the water passing through it and simultaneously adsorbs and removes taste-producing chloro-products that may have been formed together with

other taste-imparting elements. That is to say, powdered carbon when dispersed, as is the case in water pre-treatment, passes through chlorinated water without combining with the diluted chlorine, but carbon in compact form as on a filter bed or that in granulated carbon units does react with the chlorine to remove it completely.

Experience indicates that probably the greatest overall economy and efficacy result from the use of mild superchlorination of the raw water, involving dosages of between one and three parts per million. These improve coagulation, oxidize organic constituents, control algae and thereafter dissipate to a marked degree in passing through the basins. Furthermore activated carbon applied to the filter influent completely removes the residual chlorine and along with it collodial constituents including taste- or odor-producing bodies.

Filters of granular carbon serve the same purpose, and there is at least one installation of such filters for the purpose of dechlorinating a clear but colored water which has been bleached by super-chlorination and contact ahead of the carbon units. Without prechlorination, however, carbon beds have their troubles and it appears that chlorine is a most satisfactory material to keep activated carbon active if not actually render it more active.

## Some Important Aspects of Prechlorination.

Prechlorination practice has expanded considerably in recent years. Possibly this has been the result of the fact that seeing is believing when it comes to benefits derived, possibly it has been due to the studies conducted by the U. S. Public Health Service at the Cincinnati Station which are given a favorable report as to the efficacy of the process (excluding bacterial efficiencies of the filters), and possibly it is the result of the increasing use of activated carbon and also the better condition of the filter units wherever prechlorination is employed.

In some instances prechlorination has been less costly than post-chlorination alone. Why? Because the use of more chlorine has made it feasible and practical for the consumer to purchase chlorine in ton containers at a much more favorable price. As a result, the total consumption of chlorine costs no more and probably less than previously, notwithstanding the increased use.

Not the least advantage to be secured from prechlorination has been the high safety factor which the process provides. A purification plant running on prechlorination has at all times a tremendous barrier between the raw water supply and the consumer, in the nature of sterile filters and coagulation basins filled with highly chlorinated water. Lapses of chlorination or dependence on postchlorination, faulty contact periods and reduced efficiencies when ammonia is employed in postchlorination become matters of secondary concern so long as prechlorination is effectively accomplished.

Recent experience at Detroit, in which prechlorination prevented possible difficulties when postchlorine dosage control tests were vitiated by misleading readings of residuals, is a case at point.

## An Ideal Plant Operating Arrangement as the Author Views the Situation.

It is probably hazardous to set forth one's views in regard to ideal filter-plant operation at this time of rapid improvements in such matters, but the author can not help being impressed with the highly successful accomplishments at certain plants, among them that at Richmond, Va., at which the following procedure is involved.

*A*. Prechlorination (12 to 25 lb. per m.g.; residual of 1 p.p.m. or more).
*B*. Adjustment of pH in coagulation control with lime or acid when required.
*C*. Coagulation by quick-mix followed by mechanical flocculation.
*D*. Sedimentation.
**E*. Powdered activated carbon applied to filter influent.
*F*. Ammoniation and postchlorination.
*G*. Adjustment of pH to 8.4 with lime.
*H*. Residual chlorine of not less than 0.2 p.p.m. found at any point in the distribution system — no complaints.

*Note: The long period of sedimentation following coagulation has rendered the use of raw-water carbon treatment of greater expense than its use at the filters in the Richmond plant. At other points carbon application to the raw water alone or split between the raw and applied water may prove more effective.

The new plant of the Lehigh Water Company at Easton, Pa., has with success recently modeled its treatment on the same pattern as indicated above and doubtlessly there are others which have had similar experience. It is the author's belief that the Richmond plant was the first to completely work out this scheme as the result of having tried variations of many kinds — including preammoniation with prechlorination.

## Some Incidental Uses of Chlorine.

The use of chlorine and hypochlorites for disinfection of new mains has been thoroughly dealt with before this Association during the past few years. The process is becoming increasingly popular.

For oxidation of manganese and iron in raw waters, chlorination is being more widely used than ever before.

For cleaning filters, superchlorination of the sand beds appears to be the most satisfactory scheme evolved. In superchlorinating filter beds, the practice is to drain the sand bed down to the gravel and while filling with influent water, dropping over the troughs, chlorine gas is diffused into the

inflowing water through large porous diffusors or chlorine water is applied from a regular chlorinator, or an injector of hard rubber, or other resistant material. The bed is allowed to remain filled to just above the sand surface with the chlorine water for 18 to 24 hours and is then vigorously stirred on the surface and washed thoroughly. The treatment is repeated until the sand becomes clean. Once clean the treatment is repeated at intervals. As a ready substitute for chlorine, strong solutions of hypochlorites are effective and simple of application. The secret of filter bed cleansing lies in the destruction of living growths and the granulation of organic films and mud around the sand grains and gravel. The resulting sharp clean sand will not create mud balls, and cracks and bed shrinkage away from the side walls are done away with. The sand in filters subjected to a series of systematic treatments looks like new sand. The cost of sand removal, washing, or replacement has been saved.

A new scheme of coagulant production involves the passage of chlorine water upward through a tower filled with scrap iron. The overflow water contains ferric chloride in weak chlorine water thus producing at one operation coagulation and prechlorination. This scheme is similar to that developed at Baltimore, Md., for the production of chloride of copper in algae control in which the dosage of copper is a function of the rate of chlorine water application at the bottom of the tower.

At certain plants chlorinated ferrous sulphate "chlorinated copperas" continues to be used as the coagulant best suited for the conditions at hand. Lately, ferric sulphate has become available at prices competitive with copperas and chlorine and renders this new material attractive because of its ease of handling and efficiency.

*The Handy Package of Chlorine.* One could hardly discuss modern practice in water chlorination without referring to the handy package of chlorine which is represented by the dry concentrated hypochlorites: "H.T.H." and "Perchloron." These products contain 62 to 75 per cent. of available chlorine, and are now widely used for incidental or emergency chlorination, cleaning filters, sterilization of mains, algae control, swimming pools, small water supplies and large reservoirs.

## Discussion.

Warren J. Scott.* It seems to me that Mr. Enslow's review of modern water chlorination practice is an excellent one and contains considerable information that is worthy of the study of waterworks men engaged in the every day practice of chlorination. It does not appear out of place to say that the author of this paper deserves commendation from the waterworks fraternity for the quality of the research work which he has carried out on this subject as an agent of the Chlorine Institute and for his promotion of coördination of various research agencies in this field throughout the United States.

*Director, Bureau of Sanitary Engineering, Connecticut State Department of Health, Hartford, Conn.

Our New England problems with chlorination are somewhat more restricted in scope than those in many other parts of the country, where raw waters are frequently highly polluted and turbid. With comparatively few exceptions, chlorination in New England is used mainly as a preventive against chance contamination of waters which are derived from relatively clean watersheds. As an example of conditions which are probably somewhat representative of New England, approximately 77 per cent. of the water supplied through public water supplies in Connecticut are chlorinated. Of these 77 per cent., only about 12 per cent. are filtered. Another estimated 15 per cent. are filtered but not chlorinated.

One point which Mr. Enslow has not discussed at length but which has been discussed at previous meetings, is the presence of interfering substances that may cause a false reading for residual chlorine by the ortho-tolidin test. Manganese in the manganic form causes a yellow color with ortho-tolidin, similar to that obtained with chlorine, as does iron in large quantities, and nitrites in fairly large quantities. We have had some trouble with the presence of manganese in some of our Connecticut supplies. The Connecticut State Department of Health has forwarded mimeographed information to waterworks officials on this subject and recommends that occasional checks be made for the presence of manganese.

The ammonia-chlorine method of disinfection is attracting much interest on the part of waterworks superintendents and has accomplished good results in many instances. It is being successfully employed at Bridgeport, Stamford and South Manchester. One great disadvantage on most of our Connecticut supplies, as mentioned by Mr. Enslow in his paper, is the short period of contact which exists on many of our systems between the points of application of chemical and the taps of consumers. There is some uncertainty as to what contact period is necessary for adequate disinfection. In Chicago, it was found that for the same chlorine dosage, the bactericidal velocity of ammonia-chlorine treatment is decidedly less during the first two hours after the treatment is applied than that obtained with the chlorine alone. The larger the amount of ammonia present, the greater is the lag of bactericidal effect. We have generally considered that a minimum contact period of 30 minutes should be provided.

I think it is well for us to proceed cautiously so as not to let down the bars and permit inadequately disinfected water to reach consumers, even though other advantages of the ammonia-chlorine treatment may be numerous. I think probably in many instances where contact periods are short, we will have to forget the benefits of taste elimination and add the chlorine considerably ahead of the ammonia. This will give adequate disinfection, improve bacterial conditions throughout the distribution system and help in the elimination of dead-end troubles, even though the chlorine may form in some cases rather objectionable chlorinous tastes that might be eliminated by reversing the order of application of the chlorine and ammonia.

It is somewhat difficult under the Connecticut conditions to measure operating results of the ammonia-chlorine treatment in the field as to the effect of the bactericidal lag upon water supplied to nearby consumers, even though samples are neutralized with sodium thiosulphate immediately upon collection so as to cut off the effect of the disinfectant during transportation to the laboratory. This is because many of our supplies show organisms of the coli-aerogenes group in 10 c.c. rather infrequently in the raw water. While it can undoubtedly be done over a long period of time, it is not so easy to measure the results on any one particular supply under such conditions as would be the case with polluted waters. With the increasing use of chloramines in water disinfection, I am wondering if some consideration should not be given to the establishment of the use of sodium thiosulphate for immediate neutralization of the disinfectant at the time of collection of sample as a routine procedure for laboratory examination, so that we may be certain that the analysis represents a true picture of the water as delivered to the consumer. I know that in the case of disinfected sewage samples, we have found that chlorinated samples even with contact periods of thirty minutes, have shown much poorer analytical results with neutralization than without.

The author of the paper has mentioned the lag in bactericidal velocities when the water has a high pH. There are very few of our Connecticut supplies that have a pH value above 7.8.

E. SHERMAN CHASE.* One thing that Mr. Enslow mentioned to which I take slight exception is the control of chlorination through the orthotolidine test as being the first scientific method of control. Prior to the introduction of orthotolidine as a control agent we were using the starch iodide test. We controlled the application of chlorine to the raw Hudson River water by the use of the starch iodide test, which was a crude test, not as sensitive as the orthotolidine test as it has now been developed, but in those days that was the best we could do. Furthermore, during the Great War it was somewhat difficult to secure the proper brand of orthotolidine.

It is also interesting to note in Mr. Enslow's paper the emphasis placed upon the refinement of water by chlorine and allied treatments as contrasted with the hygienic control of the water by chlorine treatment twenty years ago. I think I am correct in stating that the first, or one of the first water supplies to receive chlorine treatment, was here in the state of Connecticut, at Stamford. That was in 1913, exactly twenty years ago. It is quite fitting that this ASSOCIATION should have a paper on chlorination here in Connecticut on its twentieth anniversary.

Referring to the activated carbon treatment of water, I would like to ask if in the United States activated carbon has been applied directly to reservoirs. I have read of some cases in England where a water supply reservoir has been treated with activated carbon.

*Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

FRED E. STUART.* I can outline the experience of Belmont, Pennsylvania. The supply was troubled with algae growths which were combated by copper sulphate. The taste was so objectionable that the water could not be used. Powdered activated carbon was employed in the same manner as at Bath, England, in concentrations of 4.5 p.p.m. This was applied after the addition of the copper sulphate. The water close to the intake was first treated, and when it was found that the taste was greatly improved they finally treated the whole reservoir. It is interesting to know that activated carbon treatment can be used in conjunction with copper sulphate, and that would be the way it would be recommended.

EARLE DEVENDORF.† Mr. Enslow's paper I think is a very timely one, and one that has been given a great deal of thought and is based on a great deal of experience and contact.

Chloramine treatment in New York State has been very interesting. Some of the results we have been able to obtain have been phenomenal.

One of the first places in New York State that employed chloramine treatment did so primarily to control the objectionable tastes due to phenols. Experience indicates that for phenol taste prevention it is necessary to put in the ammonia before the chlorine, whereas in other cases, where treatment is just for continuing the sterilization effect, it does not make much difference, apparently, whether the chlorine is added ahead of the ammonia or the reverse.

I should like to ask Mr. Enslow as to his experience in making the orthotolidine test. If the sample is collected ten minutes after dosage, or presumably shortly after the application of the chemical, as against collection of the sample after thirty minutes or an hour's contact, what is the experience as to the true conditions of the supply? For instance, in swimming pool control where chloramine was used we require that a predetermined amount of thiosulphate be added to the sample so that immediately upon collection the excess of chlorine is dissipated in order to determine the bacterial quality of the sample at the time of collection rather than the quality, after some longer contact with the chloramine. What is the proper procedure in collection of samples?

MR. ENSLOW. It depends on how much residual chlorine you want to carry into the system. Realizing that the use of the ammonia cuts down the rate of dissipation of the chlorine, you can see very clearly that a lot depends on how many minutes elapse between the point of application of the chlorine and the ammonia before you make the orthotolidine test. It is not like straight chlorination, which acts very quickly, in which event you get the same result after ten minutes as you will after forty, for example. Furthermore, you will find that there is an absorption of the chloramine chlorine even out in the system, due to its absorption by the organic matter which is originally in the water and on the inside of the pipe system. That

*Industrial Chemical Sales Co., New York, N. Y.
†New York State Department of Health, Albany, N. Y.

is especially true on dead ends. So that I would say that it is a matter of determining at the control point what residual one must carry in order to get a desired residual out in the system, and I do not know of any way of doing that except by the cut and try method; and, to be safe, starting at a high value and working down to the most economical point which is safe in practical operation.

MR. DEVENDORF. We use thirty minutes now. Are we right?

MR. ENSLOW. I think that is good practice. I would not be sure that I would not test again after an hour or two, just to make certain that I still got the same residual. The question might have been, how much contact period one should allow after adding orthotolidine — an interesting question.

MR. DEVENDORF. Answer that, please.

MR. ENSLOW. Detroit got into trouble because they followed Standard Methods in making the orthotolidine test on ammonia-chlorine treated water. I do not wish to criticize Standard Methods, but I must call your attention to a condition met in Detroit. They followed Standard Methods, allowing thirty minutes after adding the orthotolidine before making their comparison. They actually found though, that the color reached a maximum much before that period and then faded out gradually. Why was that? That is simply answered, when you understand that when adding the acidic orthotolidine solution you are lowering the pH value, and you do not get the color reaction until you get a pH of about 2. When you get the pH down to 2 you are producing nitrogen trichloride (trichloramine) from either dichloramine or monochloramine. You can hold the chloramines by raising the pH value, but in doing that you lose some of the available chlorine. Going from the high pH to one lower, you do not seem to lose available chlorine, you do convert it to a more aggressive form, and you get an agent which attacks some products which the dichloramine or monochloramine does not attack. That means, too, an increasing color production for a while after adding the orthotolidine, which reaches a maximum after some lapsed time and then the chlorine being gradually dissipated the yellow color drops off.

My candid opinion is — and I am going to stick to it until somebody proves I am wrong — that the maximum color that one gets after adding the orthotolidine, whether it is two minutes or five minutes or ten minutes, is the most nearly correct reading to take.

When using the ammonia-chlorine treatment, it is true that in cold weather there is a considerable lag in the maximum production of color with orthotolidine. It may run as much as fifteen minutes, but if you wait longer than fifteen minutes you are likely to get most any thing, which is capable of reaction, with orthotolidine. My experience has been such that I would rather use ten minutes than fifteen. If the maximum appears at five minutes I would take it. The effect is more pronounced in sewage testing than in water — this, because there is more organic matter in sewage.

In answer to the other question, I would say that I would allow a contact period of thirty minutes before putting the orthotolidine in, and then allow sufficient time to be sure of securing the maximum color development up to fifteen minutes or possibly longer if the water sample is very low in temperature—say 10° F. or less.

A MEMBER. In letting the sample stand, is there any possibility at all that the ammonia would undergo slow oxidation and form nitrites?

MR. ENSLOW. No. Nitrites are formed from the ammonia added, almost entirely by biological action of nitrifying bacteria. Particularly is this noted when ammonia is added ahead of non-sterile filters—and, out in dead ends where the chlorine has been exhausted.

The MEMBER. You feel it is impossible to do that by chemical means?

MR. ENSLOW. I would not want to make a flat-footed statement of that kind without looking further into the matter. I will say this: That there have been some reports that nitrites seem to be built up in the distribution system when using ammonia-chlorine treatment. Whether or not that might be due to the slow oxidation of ammonia by the chloramine or hypochlorous acid, I hesitate to say. As a matter of fact, I think there is a bit of misleading information on that point. I am not at all sure the false color, if any, is due to nitrites, as some believe. This, for the reason that in taking samples of activated sludge effluent, and other effluents, it is remarkable how much nitrite nitrogen you can have and not get any color with orthotolidine. In other words, if nitrites in reasonable quantities had interfered with orthotolidine in practice we would have been in difficulty with control of sewage chlorination some time ago. I for one can't think that it is nitrites. Not that nitrites are not present when you make the test, but that is far from proof that the nitrites are responsible. I think it is really a break-down product from the ammonia-chlorine compound that gives you this interference, because it is a fact that some of these compounds are very slow to produce color with orthotolidine. Further, the nitrite reaction gives a brownish color and chlorine a greenish yellow.

MR. SCOTT. Has any research work been undertaken recently, or is there any research work under way now to develop any reagent other than orthotolidine that is specific to chlorine without being affected otherwise?

MR. ENSLOW. During the last five years there have been a number of attempts to discover an indicator which would replace orthotolidine, but to date there is none that has proved satisfactory. Every indicator that one would use apparently depends upon the oxidizing effect. There is one basic principle involved, and that is that you have a colorless compound and you oxidize it and produce a colored compound, and that is why permanganate, manganate, manganese, and high nitrites all interfere. Hydrogen peroxide will do it when present in high enough concentration. A study is going on now at the New Jersey State Department of Health laboratories which involves the use of methyl red, in which a standard methyl red solution is dropped into the sample of chlorinated water. The

concentration of chlorine is a function of the quantity of the red dye the sample will bleach to colorless. The attempt is an interesting one but when it comes to determination of chloramine-chlorine I fear there are difficulties to be met. Any one who wants to do a real favor for this profession should evolve or suggest a test which will prove specific for chloramine or chlorine, and when he does that all the chemistry text books will have to be rewritten.

FRANCIS H. KINGSBURY.* It occurs to me that perhaps from a bacteriological control and safety point of view thirty minutes might be on the safe side. From a control of the quantity of chemical used perhaps maximum color might be obtained earlier, but wouldn't the standard of thirty minutes be a safer procedure to one who was not supposed to maintain fine control of the chemical?

MR. ENSLOW. I think it would not be unsafe. It was unsafe in the case of Detroit. You see there the thirty-minute reading was higher than the fifteen-minute reading.

MR. KINGSBURY. Higher color?

MR. ENSLOW. Yes. That meant that they were going under the false assumption that they had a certain residual there and they did not have it.

MR. KINGSBURY. Didn't you take the highest color, whether it was ten minutes or fifteen?

MR. ENSLOW. But I did not go as high as thirty minutes. I said, up to fifteen minutes. I am not sure I would go that high for safest practice in chlorine control.

MR. KINGSBURY. Then there appear to be two peaks in the color?

MR. ENSLOW. That is right.

MR. KINGSBURY. One would indicate chlorine, and the second peak, which might be higher, would indicate something else?

MR. ENSLOW. Yes, that is right but is rarely encountered except where manganic or ferric compounds are present in an organic water or sewage.

GORDON M. FAIR.† Mr. Devendorf mentioned the application of the chloramine process to swimming pools. I would like to ask Mr. Enslow whether he thinks the use of chloramine in swimming pools is here to stay. As I see the matter, what we are attempting to do with swimming pools is to disinfect whatever materials are discharged from one person before they reach the next person.

MR. ENSLOW. I believe that the ammonia-chlorine treatment of swimming pools is very much here to stay. First, it makes a very much more pleasant swimming pool to use if the ammonia-chlorine treatment is employed, and people will use the pool more than otherwise. I have had experience in that direction, and I know that there were a lot of complaints and little use of swimming pools when chlorine alone was used, whereas in going over to the ammonia-chlorine treatment the patronage increased rapidly.

Secondly, I believe from all I have seen that it is certainly possible to

*Massachusetts State Department of Health, Boston, Mass. †Harvard University, Cambridge, Mass.

carry a higher residual chlorine with equal effect. You see, this is all a matter of temperature, mass reaction, nothing else. As I see it, the rate of fall is a function of the oxidative effect or potential—possibly the dissociation factor. If 0.5 p.p.m. of residual chlorine will do the work with ordinary chlorination, probably 1 p.p.m. of residual will do it with the ammonia-chlorine treatment. That is about a 2 to 1 ratio in the residuals required for comparable disinfection in short periods. The swimming pool that is used by few people is not a dangerous pool, and never was. But where you get a large concentration of bathers, when you are using ordinary chlorination it is not very long until all protection is gone. You can't start a pool in the morning with enough residual chlorine in it, and get people to go into it, to be effective during the entire day of use. Ordinary chlorine residual is used up because of its activity. When one forgets the little things and looks at the fundamentals of this problem of pool sanitation the advantage of the ammonia-chlorine treatment in swimming pools becomes better appreciated.

E. T. Cranch.* Would you consider it safe, in view of what Mr. Scott says, to attempt to use ammonia in a supply that is not filtered, in a case where the consumers are attached to a line within 200 feet of the pumping station? Is it possible to raise the dose to a sufficient amount to insure a supply of acceptable water and still get the benefit of the ammonia?

Mr. Enslow. I would answer, "No," on that, just to be safe. Here is the case in Chicago, for example. Chicago turned down the ammonia-chlorine treatment two years ago (1931) absolutely on the basis of the fact that it took an hour and a half or so to get effective disinfection. You know, in Chicago they put the chlorine in and then drink it right now, chlorine and all, I mean. But with a study of these problems frequently you can find a way out. Chicago's way out has been this: They have gone way out in the lake to the intake crib, and are putting the ammonia-chlorine treatment in at that point, in order to avail themselves of the contact period in the tunnel between the intake crib and the shore line. They have gone to that after at one time having just thrown up their hands saying, "No, we can't possibly use the ammonia-chlorine treatment." At times a thing may look very difficult, but as you give it a little study it may work out. My candid opinion is that there is going to be a good deal in the way of adapting the ammonia-chlorine process by putting in the chlorine first and then the ammonia. Of course that can not be done if the water contains impurities to produce byproduct tastes.

Samuel M. Ellsworth.† There is one point that Mr. Enslow brought out in his paper which I think might be emphazised. In regard to the ammonia-chlorine treatment, it is possible to use larger amounts of chlorine and still obtain proper disinfection without the resulting bad tastes. In Massachusetts we have quite a number of small towns taking their water supplies from ponds and small reservoirs. Many of these supplies are

*New Rochelle Water Co., New Rochelle, N. Y. †Consulting Engineer, Boston, Mass.

chlorinated, and it often happens that the waters are rather highly colored with a varying organic content in the water due to the vegetation on the water shed.

It is natural to attempt to keep the chlorine down and to eliminate the chlorine taste as far as possible. The control of residual chlorine I think is not all that could be desired. The chlorination is oftentimes set to give a certain residual under certain conditions, and there it remains.

Mr. Enslow points out that, using the ammonia-chlorine process, the amount of chlorine can be increased materially without causing tastes, and I think that this would apply especially to the small supplies of this kind, where the operators are more inclined to govern their actions according to complaints from tastes than from the maintaining of the proper hygienic quality of the water. Take a sudden freshet in the fall, when the organic content of the water increases suddenly. They have been using, let us say, 1 p.p.m. of chlorine all summer, and the chances are pretty good that they will continue to use 1 p.p.m. during the heavier load, and the residual chlorine may be reduced very materially. I feel that the ammonia-chlorine process as applied to such supplies would be very valuable.

There is one other thing I want to say. Mr. Enslow pointed out what you might call a model treatment, and of course it might not apply in New England but it might apply in the Middle West, perhaps. That is the use of chlorine, ammonia, lime, and many other things. I am perhaps a little conservative, but my feeling is that as far as possible we should try to encourage the use of our natural waters. I do not believe that we know yet the physiological effects of all the chemicals we may add to water supplies. As many of you know, the Massachusetts Department of Public Health has always been inclined to favor slow sand filtration as against mechanical filtration, with the use of alum or coagulants. I feel in a way that perhaps that attitude is justified, because I do not see where the end is going to be in the matter of adding chemicals. I do not want to appear ultra conservative, but I do think that there is that point to be considered, that wherever possible we should consider the hygienic quality of the water first, and if it is a matter of filtration versus the addition of many chemicals, we should give serious consideration to filtration; in other words, we should come as close to getting the natural water supply as we possibly can.

MR. ENSLOW. I do not think anybody in the world can object to that attitude. We just naturally find, however, that where one is up against it temporarily, until such time as he can obtain the natural or God given purity, he has to do something about it.

## BEST METHODS OF CUTTING LINED PIPE.

*Superintendents' Discussion, Lead by David A. Heffernan.**

[*September 21, 1933.*]

I am greatly interested in the subject "Best Methods of Cutting Lined Pipe" which was discussed at the American Water Works Convention in Chicago in June, 1933. Various speakers expressed their views in regard to making the cuts; the tools mentioned were the wheel cutter, dog chisel and the diamond point. Yet, I have come home from Chicago still in doubt as to what is the best method for cutting lined pipe, especially de Lavaud pipe. If I have remembered correctly, Mr. Newsom during his discussion seemed to favor the use of the dog chisel. From the following opinions, which were voiced at Bridgeport in September, there may be gathered some information which may be of value in the future when pipe cutting.

Several kinds of pipe were discussed. Let me quote the remark of Mr. Gibson,† who has been using cement lined pipe since 1922. "We have purchased standard pit-cast pipe, de Lavaud centrifugal cast pipe, and Monocast and Sandspun pipes, and have handled them all without increase of cost or breakage." In speaking of cement-lined pipe, Mr. Gibson explains, "At first we handled it with kid gloves so to speak, fearing that jarring or hammering would cause the cement lining to shell out and leave the pipe. Experience, however, has taught us that this extreme care is unnecessary. *Cutting:* "We have used the ordinary form of cold cut and sledge hammer for cutting the pipe, as well as the improved wheel type of cutters. We find either process to be perfectly safe in handling; we do find, however, that the wheel cutter tends to cause the cement to break out further back into the pipe from the cut edge than it does with the use of the ordinary cold cut cleaver, and sledge. Just exactly why is hard to satisfactorily explain."

In Milton we have been using cement lined mains for a period of eight or nine years with very good results. In cutting de Lavaud pipe we use the wheel cutter and on Sandspun pipe the dog chisel and sledge. Both of these methods do not materially disturb the lining of the pipe. Various tests were made in cutting of the de Lavaud pipe before our present method was adopted.

PERCY S. WILSON.‡ Do you refer to the straight edge chisel or the diamond point?

MR. HEFFERNAN. The straight edge chisel.

ROGER W. ESTY.§ I have used both kinds of pipe, sand spun and U. S. In fact, from information that I get this year, the U. S. concern claims that they have a pipe which is equal to the sand spun pipe, that you can

*Superintendent, Milton, Mass. †Commissioner of Public Works, Charleston, S. C.
‡Superintendent of Operation, Community Water Service Co., New York, N. Y.
§Superintendent, Danvers, Mass.

bang it and cut it, and do anything you want to with it and it will act just the same. We did have some sad experiences in the beginning, but with both types of pipe. I make all cuts with a wheel cutter, using double chain tongs, one going each way. My men would rather use the wheel cutter than to use the hammer and chisel. It makes a better cut and does not disturb the lining. It is practically a one-man job that way, and you do it faster.

PRESIDENT ELLIS. How large pipe do you cut?

MR. ESTY. We cut 12-in. pipe that way.

PRESIDENT ELLIS. What about pipes of larger diameter.

MR. ESTY. We have done the cutting with hammer and chisel up to 20-in. pipe.

PERCY R. SANDERS.* I have cut de Lavaud and sand-spun pipe up to 12 in. in diameter. We always use chain tongs and a wheel cutter. On the old style, pit-cast pipe, we used what Mr. Heffernan calls the dog cutter, or cold chisel. We find we have better luck cutting pipe with the wheel cutter — either kind of pipe.

W. R. CONARD.† If I were cutting pipe I would use neither the dog chisel nor the wheel cutter; I would use a machine cutter. I believe that this is the only logical equipment to use on any kind of pipe. You get a clean cut; you have a piece of pipe you can use over again if you take the section out. If you use a machine cutter there is no question as to injury, whether you are dealing with tar-coated, cement-lined or bitumastic-lined pipe.

MR. HEFFERNAN. Mr. Conard's remarks are very good. If there can be placed on the market a cutter that will not cost as much as $500.00 and one that can be carried around on the job without having to obtain different sizes and running up expenses, I will agree with him. If he can recommend some machine cutter at a low cost we will consider it.

MR. CONARD. There is a machine cutter that is produced in Ohio for 4, 6, and 8-inch pipe, which costs $75;

MR. HEFFERNAN. That is reasonable enough.

MR. CONARD. We have them and use them.

MR. ESTY. Is that cutter hand-operated?

MR. CONARD. Yes.

MR. ESTY. How long does it take to set up the machine?

MR. CONARD. Not more than five minutes.

MR. WILSON. I agree with Mr. Conard's remarks. I want to ask him if he does not think that a skilfully used diamond point is about equivalent to the cutter, because the skilfully used diamond point is something that can be applied without the first expense of the cutter, and if the men are skilful they can cut off the pipes so that the ends are nearly as true as when a machine cutter is used. At the same time, a diamond point does not deliver the shock to the pipe in such a way that it cuts out a piece of metal and does not tend to shatter the same as a straight edge.

*Superintendent, Concord, N. H. †Inspecting Engineer, Burlington, N. J.

MR. CONARD. That would depend upon whether you are cutting it on the bank or in the trench. If you are cutting the pipe on the bank you can with very good success use a diamond point to make your cut, but if you are working in the trench, there would be only one answer for me.

MR. WILSON. You can't use the diamond point in the trench unless you can revolve the pipe.

# THE DAYS OF SMALL THINGS.

BY CHARLES W. SHERMAN.*

[*Received October 15, 1933.*]

A report of the Directors of the Cambridge, Mass., Water Works for the year 1860 is interesting particularly as showing what small sizes of pipes were considered adequate for a city of 26,000 persons. The works had been in operation only three or four years,† and included 124 517 ft. of pipe, as follows:

| Diameter of Pipe—inches. | Length—feet. | Per cent. of Total |
|---|---|---|
| 20 (intake) | 180 | 0.1 |
| 12 | 5 950 | 4.8 |
| 10 | 13 180 | 10.6 |
| 8 | 6 000 | 4.8 |
| 6 | 14 955 | 12.0 |
| 4 | 56 263 | 45.2 |
| 3 | 27 989 | 22.5 |
| Total | 124 517 | 100.0 |

No description of the pump or reservoir is contained in the report, but city records furnished by Hon. T. W. Good, Superintendent of the Water Works, show that there were two Worthington pumps each of 1.5 m.g.d. capacity, and that the reservoir, which was 73 ft. higher than Fresh Pond, and was at the corner of Reservoir and Highland Streets in Cambridge, had a capacity of 1 764 000 gal. after being rebuilt and enlarged by the city in 1867. The total number of customers is not stated in the old report, although there was a gain of 575 during the year.‡ The estimated revenue from water rates for 1861 was $20 000.

"About the middle of July a second fireman was employed, and from that time to the present the pumps have been worked 24 hours per day. . . Besides the saving in wear and tear of the machinery, we find a saving of 2 400 pounds of coal and 145 pounds of wood per week, notwithstanding the quantity of water raised is increased. This saving is sufficient to meet a large portion of the expense of an extra fireman, for which we pay $32 per month."

The estimated operating expenses for 1861, namely all expenses except interest, dividends, and sinking fund charges, were $5 500, as follows:

*Of Metcalf and Eddy, Consulting Engineers, Boston, Mass.

†The corporation was organized in 1853.

‡This appears inconsistent with the total number of water takers (300) at the time the works were acquired by the city of Cambridge in 1865.

| | |
|---|---|
| Salaries of officers | $2 000 |
| Expense at the pond | 3 000 |
| Incidental expenses | 500 |
| | $5 500 |

During the first year of the city's ownership, 1865, the receipts were $32 367, and the expenditures $25 170. The salary of the superintendent was $625. The average daily water consumption was 975 000 gal.

Can there be any doubt that 1860–61 represented the days of small things, so far as water works were concerned?

# RECENT ADDITIONS TO THE CAMBRIDGE WATER SUPPLY.

BY HOWARD M. TURNER.*

[*Read on November 8, 1933.*]

*Existing Water Supply.* The water supply of the city of Cambridge was taken originally from Fresh Pond in Cambridge in 1856. This supply was supplemented in 1887 with water brought in a conduit from a storage reservoir constructed on Stony Brook, a tributary of the Charles River, in Waltham and Weston. In 1897 larger storage reservoirs were completed on Hobbs Brook, a tributary of Stony Brook, in Waltham, Lincoln and Lexington. The water from the Hobbs Brook reservoirs flows in the channel of Hobbs Brook to Stony Brook Reservoir and is drawn through a conduit to Fresh Pond, whence it is pumped for the supply of the city. See Fig. 1.

Stony Brook reservoir contains 402 m.g. of water. The dam is of earth and is founded on the natural material, a large part of which is of a sandy and gravelly nature and there is reason for believing that considerable leakage occurs. The total drainage area is 23.75 sq. miles and the net drainage area below Hobbs Brook reservoir is 16.5 sq. miles. The reservoirs on Hobbs Brook are much larger than the Stony Brook reservoir, containing when full approximately 3 000 m.g. The watershed area directly tributary to the Hobbs Brook reservoirs is only 7.25 sq. miles.

From Stony Brook reservoir the water is carried to Cambridge by gravity. For the first 4 300 ft. the pipe was cast iron, 36-in. in diameter. Thence there were 8 700 ft. of 30-in. cast-iron pipe extended through the Mt. Feake Cemetery and along the Charles River between the railroad and the river, across Newton Street to the beginning of a concrete conduit. The concrete conduit is 26 700 ft. long, 63-in. in diameter, laid on the hydraulic grade line with the exception of three siphons, and extends to Fresh Pond where a short length of 40-in. steel pipe leads to the filtration plant and an overflow weir permits discharge into the pond. The capacity of 12 000 ft. of cast-iron pipe with Stony Brook Reservoir full was 14.7 m.g.d. and less with the reservoir drawn down. This was barely sufficient to serve the needs of Cambridge at the time. The 63-in. concrete conduit, on the other hand, has a capacity running full of about 33 m.g.d., and may therefore be considered to be ample in size for any possible future use.

Fresh Pond is a natural lake in the western end of the city with an area of 88 acres. It contains when full a total of 1450 m.g.; 400 m.g. of this were available by means of low-lift pumps in the purification works. Water thus taken from Fresh Pond could be replaced by excess water from Stony Brook and by the natural runoff of the Fresh Pond watershed, estimated to be about 1.25 sq. miles.

*Member of Cambridge Water Board, Cambridge, Mass. and Consulting Engineer, Boston, Mass.,

The purification works were built in 1922 on the shores of Fresh Pond. They are of the mechanical or rapid sand filter type. There is a receiving chamber into which water is introduced either directly from Stony Brook, or by means of the pumps from Fresh Pond. From the receiving chamber the water flows into the coagulation basin, a covered masonry structure of

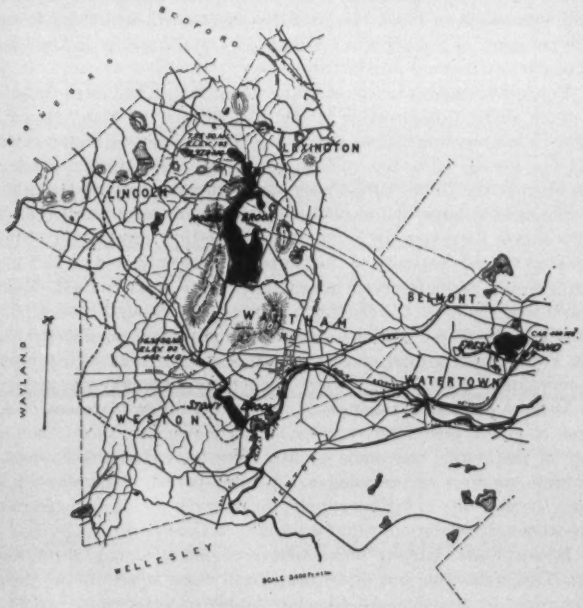



FIG. 1.—PRESENT CAMBRIDGE WATER SUPPLY.

1.5 m.g. capacity, divided in the center for ease of cleaning. After subsidence in this basin the water is brought directly to the pipe gallery of the filter plant, which comprises 10 units of an area of 480 sq. ft. each, and having a total nominal maximum operating rate of 120 m.g.d. per acre or a total capacity of 14 m.g.d. From the filters the water flows through an aërator to a covered concrete pure-water reservoir located under the filter beds holding approximately 4 m.g.

The pumping station is located near the purification works and is supplied from the pure water reservoir. The pumping station contains a new 20-m.g.d. Worthington cross-compound steam pump put in three

years ago and three other older pumps with a total capacity of 30 m.g.d. The water is pumped up to the distribution reservoir in Payson Park holding 22 m.g., whence it goes to the distribution system through a 40-in. steel main.

In 1930 there were 16 800 services of which 9 000 were metered.

*Proposed Enlargements.* Late in 1929 the matter of additions to the water supply were considered. The consumption had grown to over 13 m.g.d. equivalent to about 115 g.p.d. per capita with something in excess of 50 per cent. of the services metered (Fig. 2*). Pressure in the eastern end of the city was not satisfactory.

Possible methods of increasing the water supply had been considered for many years. Consideration of the capacities of the Stony Brook and Hobbs Brook reservoirs shows that Stony Brook Reservoir with a capacity of 24 m.g. per sq. mile is too small to store all the water from its catchment area whereas the Hobbs Brook reservoirs with a capacity of 410 m.g. per sq. mile are too large, the result being a waste of water every year from Stony Brook Reservoir. In a report made in 1912 Frederick P. Stearns estimated the safe capacity of the system as it then existed at 11.5 m.g.d. Raising Stony Brook reservoir later increased this to 11.7 m.g.d. Fuller & Everett recently rated the existing capacity of the Stony Brook supply at 12.1 m.g.d. in a 95 per cent. dry year with an additional possible 0.9 m.g.d. from Fresh Pond, a total of 13 m.g.d. It was clear that with a growing consumption of over 13 m.g.d. some extension of the supply was necessary.

Definite steps were taken early in 1930 by the employment of Allen Hazen to give a preliminary opinion and in November, 1930, a complete study of the system was made by Mr. Everett of Hazen & Everett. At that time we were experiencing a low-water period which showed very clearly the necessity of further supply, the reservoirs being depleted so that there were only 50 days of water remaining in the system.

*Driven Wells.* Various plans were considered; among them driven wells. Test wells were put down near Fresh Pond where it was thought water might be obtained. An adequate supply of water which would not require filtration or carrying long distances in a pipe line presented an attractive possibility. Six test holes were drilled to bed rock at varying depths from 94 to 173 ft. The character of the material encountered was such that it was felt that there was no assurance that the underground supply was sufficient. The water found was extremely hard and even when mixed with the other water would have raised the hardness of the whole supply from 45–60 to over 60–90 p.p.m. depending on the proportion of water from the driven wells.

*Use of Stony Brook Waste.* The recovery of the water wasted at Stony Brook Reservoir, amounting on an average to about 2 700 m.g. a year (7.4 m.g.d.), has long been considered a possible additional supply. Mr.

*Fig. 2. shows actual quantities from 1890 to date, the predictions made in 1912 by L. M. Hastings, City Engineer, which compared very closely to those made at the same time by F. P. Stearns, Consulting Engineer, and also those made in 1930 by Fuller & Everett.

Stearns in his report of 1912 proposed pumping this excess water from Stony Brook back into the Hobbs Brook reservoirs. At various times it has been suggested that the level of the banks of Fresh Pond be raised so that additional water could be stored there. The plan now investigated was the

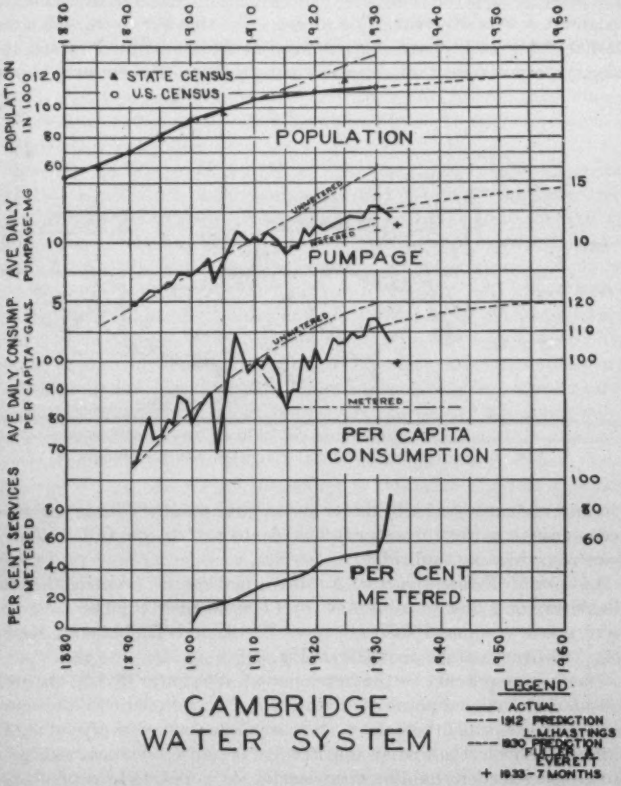



FIG. 2.—POPULATION, PUMPAGE, CONSUMPTION AND METERAGE OF CAMBRIDGE SUPPLY.

use of more of the existing capacity of the pond. Soundings showed that it is very deep, 55 ft. in the deepest place, and the additional storage to take care of the overflow from Stony Brook as it might be necessary could be stored if the water could be drawn low enough to make room for it. The

existing limit of draft, 9 ft., with the pumps available allowed a storage of 400 m.g. A draft of 30 ft. would make immediately available 800 m.g. additional. By increasing the size of the conduit leading from Stony Brook so that some of the flood water from that reservoir could be carried into Fresh Pond it was estimated that approximately 1.9 m.g.d. could be added to the present supply making a total dependable yield of about 14.9 m.g.d. throughout a very dry year. The total cost of this work was estimated at $275 000. The yearly charge for pumping would be small as it would not be necessary to pump very much except in dry years. The amount of pump-

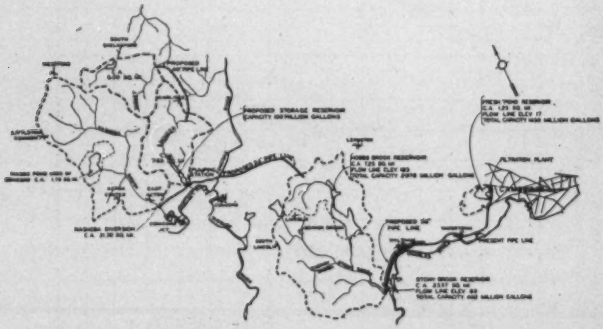


FIG. 3.—PROPOSED ADDITIONAL SUPPLIES FOR CAMBRIDGE.

ing in any ordinary year will be for about three months. This was clearly an economical source of water which developed to its full extent the present resources of Cambridge.

*Additional Future Sources.* An investigation of additional sources available beyond this was also made by Fuller & Everett. The most promising of these was found to be Spencer Brook and Tophet and Nashoba brooks, tributaries of Assabet River (Fig. 3).

The first step would be the development of Spencer Brook, the area of which at the proposed point of diversion is 7.5 sq. miles. The catchment area is fairly clean and there are no towns or large sewers except that of the Middlesex School. There is an opportunity for an economical storage reservoir in that section enabling the water of the brook to be stored so that the pumping plant and diversion pipes may be smaller. The development would be carried out in two steps as the water was needed. The first would be a small dam storing about 100 m.g. on an existing pond and a pumping station with a capacity of 8 m.g.d. with a 24-in. pipe about 30 000 ft. long to the Hobbs Brook reservoirs. This would add 4 m.g.d. to the capacity of the system in a 95 per cent. dry year. The cost of this work was estimated to be $600 000.

The second step would be increasing the size of the reservoir by raising the water level 26 ft. impounding approximately 2 billion gallons of water. Additional drainage area from Tophet Brook with 6 sq. miles of catchment area would be brought in by gravity into this reservoir. Additional pumps and a second pipe line to Hobbs Brook would be installed. This step would add an additional 5 m.g.d. making the total yield from the Spencer Brook watershed 9 m.g.d. The cost was estimated to be $1 120 000.

Nashoba Brook drainage area is directly west of that of Spencer Brook. The area above the point of proposed intake is 21.3 sq. miles. Should it be found necessary to supply more than the 9 m.g.d. additional to the present supply this area presents another possible source. An additional 3 m.g.d. could be obtained by this.

*Entering the Metropolitan System.* Another plan considered was entering the Metropolitan System. Cambridge did not enter the Metropolitan when it was formed in 1895. The subject has naturally come up from time to time and was raised in 1920 at the time the matter of filtration was being considered, but it was decided then to use Cambridge's own supply with filters. The Metropolitan District was approached in 1930 to see on what terms Cambridge could enter in order to provide for additional supply needed then and in the future. It was found that Cambridge would be required to pay an entrance fee of $2 620 000 plus a yearly assessment covering its share of the cost of maintaining and operating the works based on the ratio of its population and consumption to that of the other municipalities of the District. The Commission estimated that this assessment under the conditions then existing would amount to $312 000 a year. If Cambridge should operate its own works it would be allowed a rebate of $44 per m.g. on all such water produced. The $312 000 per year amounted to about $66 per m.g. so that the net cost to Cambridge for water produced from its own works would be $22 per m.g. To this would be added the fixed charges on $2 620 000. In 1930 the total expenses of running the Cambridge water works including fixed charges of interest, sinking fund and serial bond retirements was about $468 000 a year. Using Metropolitan water this cost would be reduced by an allowance of $44 on the 4 700 m.g. or $207 000 leaving a sum of $261 000. To this would be added the $312 000 yearly assessment from the Metropolitan and the interest and funding of $2 620 000 entrance fee amounting to, at 7½ per cent., $196 000, or a total of $769 000 a year, thus increasing the total yearly cost by $301 000 or an increase of 64 per cent. When this extra cost is considered from the point of view of the additional water required it is very high indeed. Clearly with this system of charges Cambridge could not possibly afford to join the Metropolitan System at present. Cambridge which had its own source capable of safely supplying about 12 m.g.d. and only needed a supply for its small increasing use would be required to pay a maintenance charge on its *whole* consumption 33 per cent. greater than the credit it was allowed and in addition an investment charge on its whole

requirement with no credit at all for its own investment in its own supply works.

In 1919 the matter of entering the Metropolitan System was also considered and at that time the entrance fee was $1 134 000. In 11 years this had grown to $2 620 000. With this system of charging it is unlikely that Cambridge can ever go in to the Metropolitan System. When the increased amount of water now obtained from the complete utilization of its own watershed is not sufficient it will certainly be advisable for it to seek its own independent supply rather than to pay an entrance fee which then apparently will be in excess of the present huge sum, and at the same time paying a yearly charge greater than the credit it receives for supplying water from its own system. The question was not really acute at this time because it was clear that the cheapest water to get was that which it now owned but wasted. The problem will become important when more water is needed.

The Joint Report on the Metropolitan Water Supply made in 1922 lists 16 cities and towns within the 10 mile radius which were not members but might be expected to join in the use of the new Ware and Swift river supplies. As far as I know none of them has yet come in. Like Cambridge many of these may not be able to afford to enter the Metropolitan System under the present methods of charging for water.

*Plan Adopted.* Comparison of these three different sources of supply, wells and utilization of the waste of Stony Brook reservoir with a future extension if required to Spencer and Nashoba Brooks, led to the decision to start the latter program at least as far as the utilization of the waste from Stony Brook. The total cost of the 2 m.g.d. including all fixed and operating charges for the increased supply and the additions at the purification works was estimated to be $71 000 a year or about $97 per m.g.

It was also decided to start on a program of metering which would complete the metering of the whole city within about 4 years, and it was expected that with the additional 2-m.g.d. supply and the slowing up of the growth of consumption by metering, additional sources of water would not be required for some years.

*Additions to Purification Works.* The increase in consumption of water required additional purification works. The original filters were 10 in number but the foundations were constructed to allow for 6 more. The engineers recommended the installation of these 6 filters and in addition the construction of a new sedimentation basin of 3 m.g. capacity.

The six new filtration units increase the maximum capacity of the plant from 14 m.g.d. to 22 m.g.d. suitable for an average output of about 18 m.g.d., a proper size for an addition at that time.

The engineers also recommended that the dirty wash water formerly returned to the coagulation basin with detrimental effects on the purification or wasted to the sewer be returned instead to Fresh Pond by a 12-in.

pipe to a point remote from the pump intakes thus saving it but giving opportunity for dilution and clarification before it reaches the intake.

*Increases in Distribution System.* The Payson Park distribution reservoir is located at the extreme westerly end of the system and is connected to the pumping station by a 40-in. steel main and to the heart of the distribution system by a second 40-in. main. This latter main passes near the pumping station and is cross-connected to it by a pair of pipes of 30-in. and 24-in. diameter.

From the termination of the 40-in. feeder from Payson Park Reservoir at the Cambridge Common, three major arteries run down through the city in an easterly direction, a 24-in. main on Cambridge St. as far as Ninth St., a 20-in. main on Broadway as far as Third St. and a 20-in. main from the Common to Mt. Auburn St. increasing to 24-in. on Mt. Auburn St. to Green St., where it again becomes a 20-in. main as far as State St. and runs as a 20-in. main on State St. to Main St. The main central thoroughfare through the city, Massachusetts Ave., is practically completely occupied by the subway so that it contains only a 12-in. pipe. There are also other arteries of smaller pipes thrown out to carry water to districts lying in the other parts of the city. These are for the most part of 12-in. pipes. Subsidiary piping in the various districts are of 8-in. and 6-in. pipe with some 4-in. pipe.

The 20-in. pipe on Broadway was very old, having been laid in 1867, and was in very bad condition from electrolysis. After consideration of several plans including (1) the use of elevated tanks in the eastern part of the city; (2) the provision of a new 30-in. steel feeder main from the 40-in. main feeder in Brattle St. to the lower end of the city, south of the subway; and (3) the replacement of the Broadway pipe with a larger 30-in. pipe, the latter was finally chosen as providing the most economical solution of the problem. In addition to this, two 24-in. pipes were carried across to the main feeder mains on the south side of the subway and various 12-in. pipes were added.

*Cost and Finance.* Early in 1930 appropriation was made of $800 000 to cover the cost of the work except the enlargement of the sedimentation basin which was postponed until a later date. It was financed by the use of $210 000 of the Water Department surplus and by the issue of $590 000 of 3½ per cent. 25-year serial bonds. The amount from surplus was used to pay for the pumps at Fresh Pond, the new filter beds, the 12-in. mains and the meters, items which if paid for by bonds would require retirement in less than 25 years.

*Fresh Pond Pumping Station.* Figures 4 and 5 show the plans of the pumps and intake at Fresh Pond. Two pumps of 7.5 m.g.d. capacity each are located in a pump chamber at the shore of the pond and two pipes, one terminating 22 ft. and the other 32 ft. below high-water level are carried out into the pond down the slope. These steel pipes are laid for the most part in a trench dredged in the bottom of the pond except in some cases

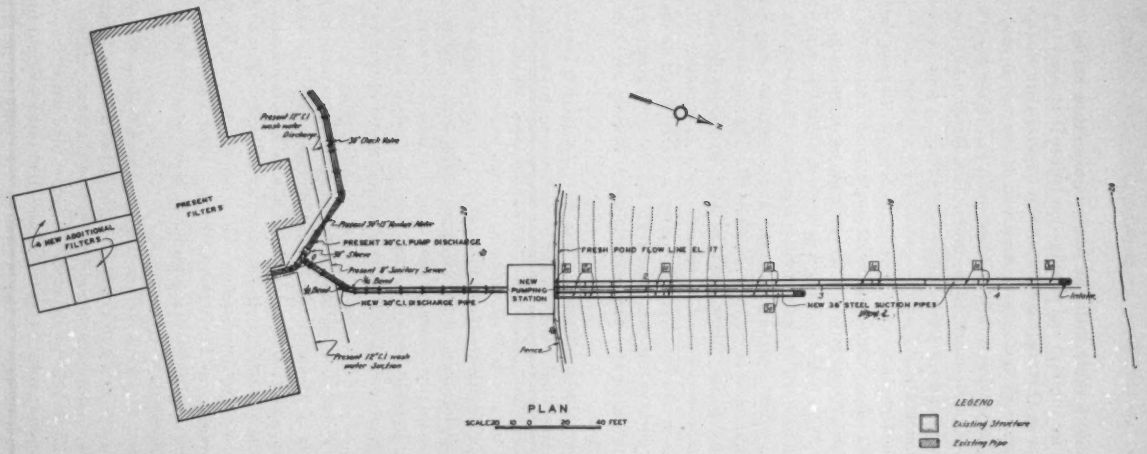



FIG. 4a.—PLAN OF NEW INTAKES ON FRESH POND.

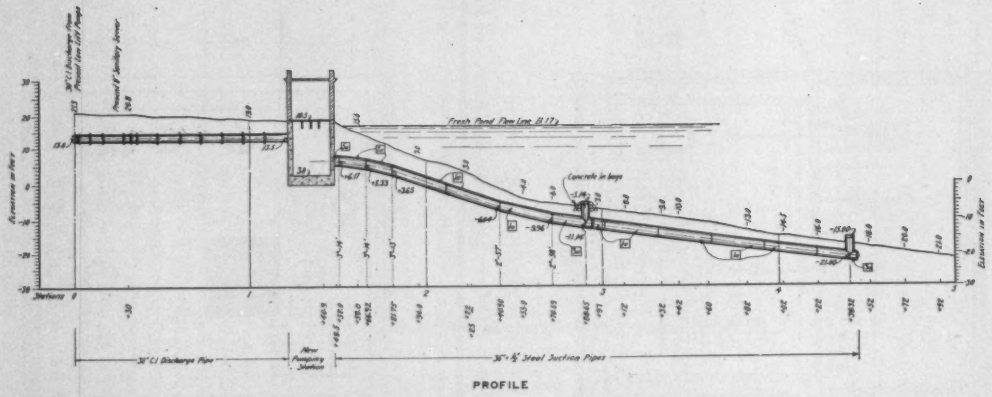



FIG. 4b.—PROFILE OF NEW INTAKES ON FRESH POND.

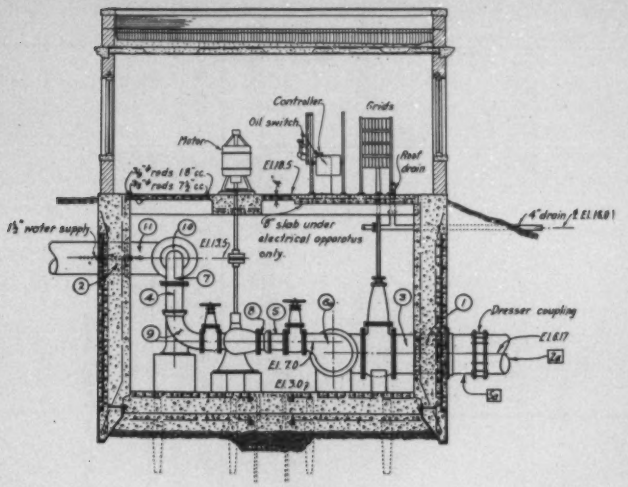



FIG. 5a.—SECTIONAL ELEVATION OF NEW PUMPING STATION ON FRESH POND.

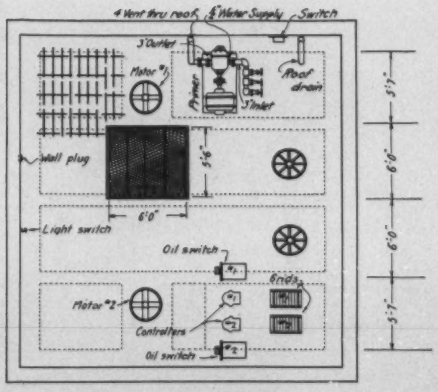
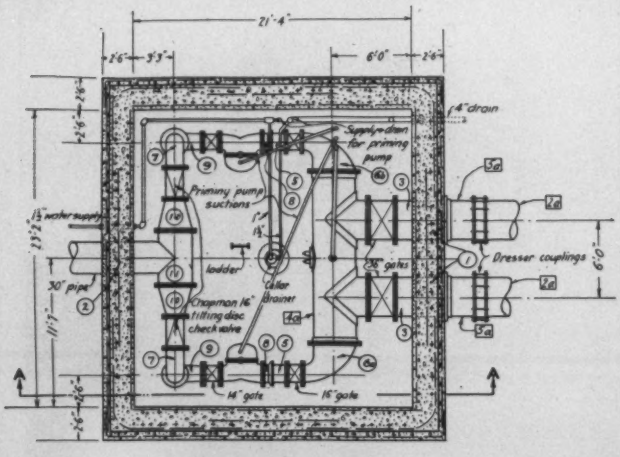



FIG. 5b.—FLOOR PLAN OF NEW PUMPING STATION ON FRESH POND.

where a soft bottom required pile cradles. The pipes are electric-welded steel pipes made by the Walsh Steam Boiler Works. They were assembled on pile trestles and lowered into place. The joints are Dresser couplings which were finally tightened up by a diver after installation. After testing the pipes for tightness the trench was backfilled. The pump house itself was excavated in the open using wooden sheeting, the contract being let to John M. Tobin & Co., of Boston. The whole bottom was waterproofed.




FLOOR PLAN EL. 3.0

FIG 5c.—BASEMENT FLOOR PLAN OF NEW PUMPING STATION ON FRESH POND.

A sump in the middle provides for pumping out any possible seepage or condensation. The pumping equipment was furnished by the Turbine Equipment Co. Fuller & Everett were the engineers.

*Waltham Pipe Line.* For the new 36-in. pipe line from Stony Brook, two alternate arrangements were considered. The first provided for a cast-iron pipe paralleling the existing pipe line for its full length. The present pipe passes through Mt. Feake Cemetery in Waltham following a narrow driveway bordered by cemetery lots with very little room for the laying of another pipe so that for some of the distance it would be necessary to substitute for the present pipe a single new 48-in. pipe. The other plan (Fig. 7) avoided this congested construction by means of a tunnel driven through rock underlying a hill in the cemetery. This shortened up the line by about 300 ft. This tunnel was about 1 800 ft. long and about 6 ft. in diameter

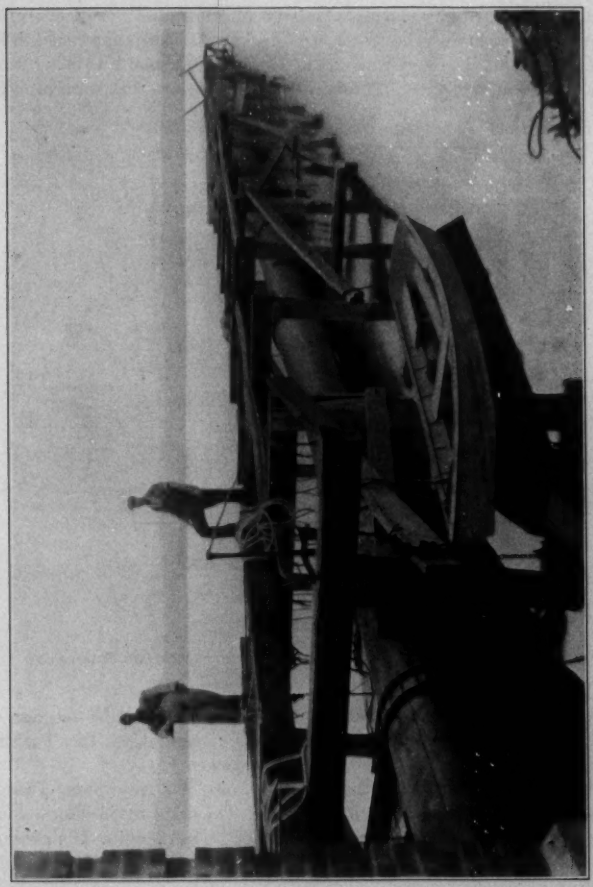


FIG. 6.—INTAKE PIPES ASSEMBLED PRIOR TO BEING LOWERED INTO PLACE.

with a 36-in. steel pipe in it. Bids were obtained on both plans. The tunnel route was estimated to cost more than the other route by about $11 000 after an allowance for rebuilding the roadways which would be disturbed on the other route. The fear of possible delay and damages to the properties in the cemetery led the Board to adopt the tunnel route even at the higher expense, this route being also favored by the cemetery authorities in Waltham. The contract for laying the pipe was let to John J. Coughlan & Co. The cast-iron pipe which extends from the lower end of the tunnel to the end of the line was furnished by the Warren Foundry Co. and the steel

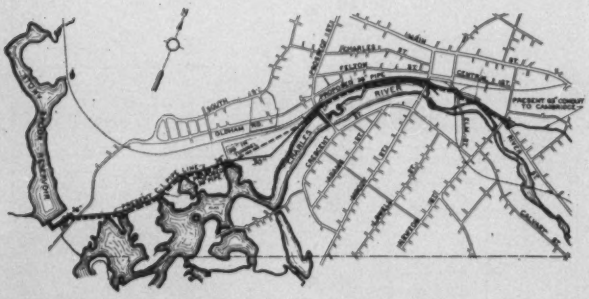



FIG. 7.—NEW PIPE LINE THROUGH WALTHAM.

pipe by the Walsh Holyoke Steam Boiler Works. The engineering on this work was done by the city engineer Mr. Hastings, and after his retirement by Mr. Hooker, with Fuller & Everett as consulting engineers.

There were many special problems in connection with the laying of the large cast-iron pipe through the streets of Waltham, under bridges, through mill yards and under the floor of a barber shop and the heating plant of a hotel, but the most interesting was that of the tunnel. It was not proposed originally to line the tunnel except where it was not in ledge but the character of the rock encountered in part of it made it necessary to line 1 050 ft. at considerable expense. Figure 8 shows the expansion joints, anchors and braces employed to prevent accumulated water from floating the pipe when empty as the invert is at times below the water level in the Charles River nearby. Ordinary tunnelling methods were used in excavation, all the work being done from the west end, the material being disposed of close to the tunnel portal in a low place which the cemetery authorities wished to have filled. The lining was placed from the west end by the pneumatic process. After the tunnel was completed the pipe was put in, three 30 ft. lengths being riveted together outside and then hauled into place on small trucks on the industrial railroad track.

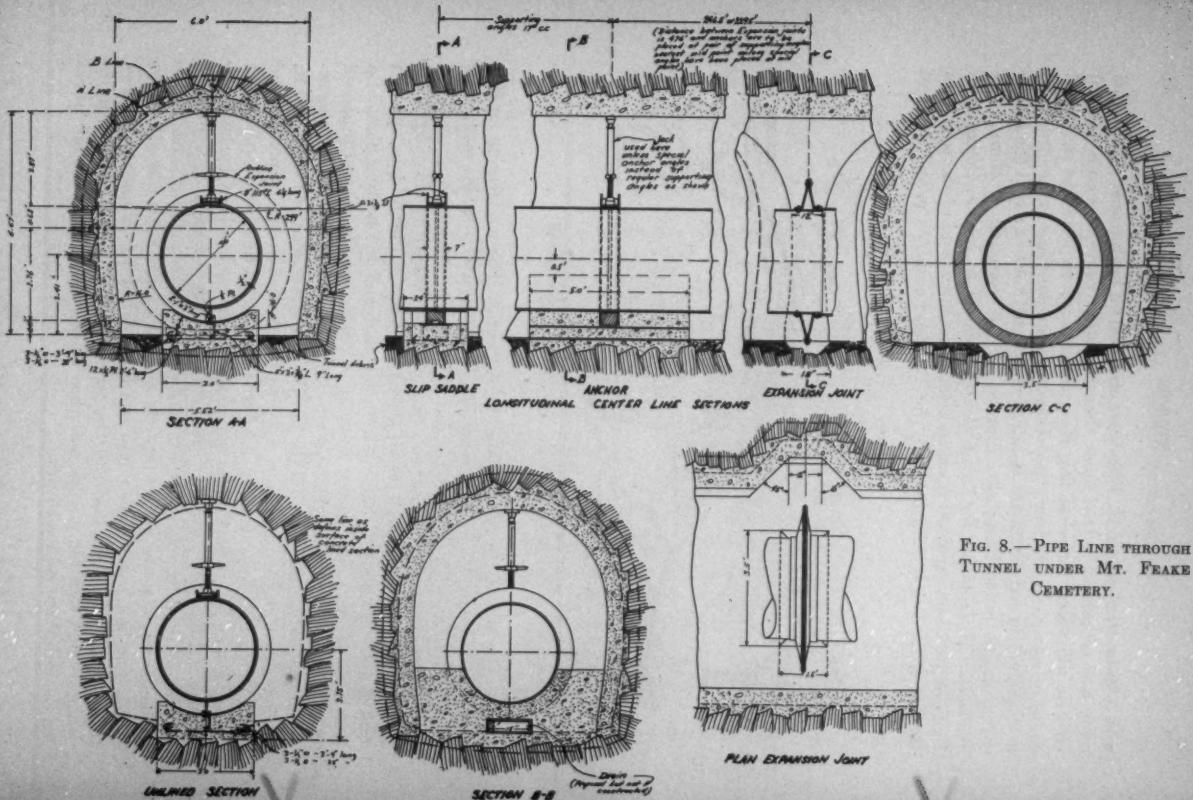



FIG. 8.—PIPE LINE THROUGH TUNNEL UNDER MT. FEAKE CEMETERY.

FIG. 9.—PORTION OF STEEL PIPE LINE BEFORE BEING MOVED INTO PLACE IN TUNNEL.

*Filtration Plant.* The work at the filtration plant (Fig. 10) consisted of the addition of six new filter beds, foundations for which were provided when the original plant was built. The filters have Wheeler bottoms the same as the original 10 beds. The piping is laid out with particular attention to the accessibility of the pipes and fittings. The wall of the building between the new and old filters was removed so that the new filters are in the same room as the old. The new wash-water disposal pipe was put in by

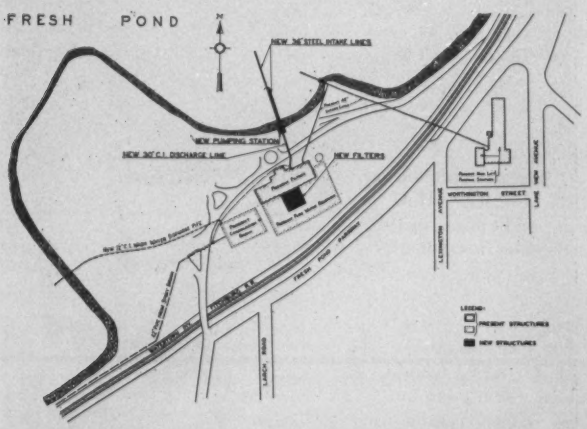



FIG. 10.—GENERAL PLAN OF ADDITIONS TO FILTRATION AND INTAKE WORKS ON FRESH POND.

the department's own men. The contract for the concrete work in the building was let to John M. Tobin & Co. The filter equipment and piping were furnished by the Roberts Filter Co. Fuller & Everett were the engineers.

*New Mains.* The new large mains in the distribution system were laid out by the city engineer's office. The Superintendent of the Water Board, Mr. Good, was in direct charge of the work. The laying of as large pipes as these through city streets with sewers, conduits and the various inter-connections and services presented the usual problems. The pipe was laid along the south side of the street, generally, just outside the sidewalk line. The tees for the inter-connections at street intersections were included, and the inter-connections on the south side made as the work went along, the services being carried over the new pipe with copper pipes. The pipe was completed in sections after connection of the services and inter-connections on the south side. After the pipe was completely filled the old pipe was discontinued in sections and the services and inter-connections on the north

side connected into the new pipe. The latter work was done by the department's own men. The pipe was furnished by the Warren Co., and John M. Williams was the contractor for laying it. The restoring of the pavement was done by the street department of the city. In most cases a reinforced concrete sub-base was laid across the top of the trench. A large part of the pavement was not completed until some time after the pipe was laid so there was ample opportunity for settlement.

The work included the inter-connection of a 24-in. pipe on Trowbridge St. and one across the lower end of the city. All the 12-in. pipe was laid by the department's own men under the superintendent's charge.

*Cost.* The work was completed with the exception of some of the interconnections on Broadway late in the year 1931 and the final figures of total cost came within $20 000 of the estimate of $800 000, the additional appropriation being required for the tunnel work chiefly on account of the extra lining needed.

The pumpage during 1931 averaged less than 12 m.g.d. and so far in 1933 11.5 m.g.d. How much of this reduction in capacity from the high point of 13 m.g.d. in 1929 and 1930 is due to meters and how much to the depression it is difficult to say. There isn't any question that the latter is a considerable factor. On the other hand the fairly complete metering now in effect has not yet shown its full effects. The present capacity of the works, about 15 m.g.d., should be sufficient to provide for a good many years in the future. The land in Cambridge is pretty well built up. We look forward hopefully, however, for a continued industrial expansion which would mean an increase in water consumption but probably not a very great population increase.

When more water is required the question of whether Cambridge will obtain its own additional supply from another area which exists within easy reach or whether it can obtain water from the Metropolitan Supply on terms that will make the cost at all comparable will again arise.

## Discussion.

Henry F. Beal.* As City Engineer of Waltham, the city through which the pipe line was constructed, I feel that I should say a word about the work. All construction was done in a workmanlike manner, every necessary replacement was made at no cost to the City of Waltham, and when the work was completed, except for a little temporary inconvenience perhaps, we should never have known that anything had happened. The handling of the work in such an efficient manner is due entirely to our good member, Timothy W. Good. We had no trouble from start to finish.

Lewis M. Hastings.† I am somewhat interested in this extension of the water works, as some of you may know. I would like to ask (1) how

*City Engineer, Waltham, Mass. †City Engineer, Cambridge, Mass.

much water can be obtained from the areas lying to the west of Hobbs Brook; (2) whether in the Broadway supply line any increase in head from the enlarged supply has been noticed; (3) whether in the tunnel section of the supply main from Stony Brook Reservoir any difficulty has been experienced in the maintenance of the tunnel.

TIMOTHY W. GOOD.* In answer to the first question, the first step of development at Spencer Brook is estimated to yield 4 m.g.d., the next step 5 m.g.d. additional, and the last 9 m.g.d. additional. In answer to the second question, the pressures along the Broadway pipe line have been raised from 7 to 11 lb. per sq. in., and that increase in pressure has extended in both directions, to the north as far as Cambridge St. As regards the third question, the water in the Charles River has been somewhat high. Although the City Engineer, Mr. Hooker, endeavored to make an inspection of the pipe, the water was such that he could not get into the tunnel to do it without pumping it out. We hope that when the water gets lower we shall be able to make an inspection. It has been in constant operation.

*Superintendent of Water Works, Cambridge, Mass.

# CORROSION OF BRASS IN WATER SUBJECTED TO pH CORRECTION.

EDWARD W. MOORE.*

[*Read November 8, 1933.*]

In recent years there has been a tendency to minimize corrosion of water supply systems, in which the ferrous metals are predominant, by increasing the pH of the water. The possible effects of this procedure on the non-ferrous parts of the system have been questioned by Pirnie in his statement at the Pittsburg meeting of the A. W. W. A., that while corrosion might be reduced by increasing pH, zinc would be dissolved by too high pH. Nor would zinc be alone in such behavior. Any metal forming soluble complex salts would be susceptible to attack. Among such salts, in addition to the zincates, may be mentioned the aluminates, plumbates, and stannates. Thus zinc, aluminum, lead and tin might be attacked by waters, of high pH. Of these, zinc is the most important, as it is included in water supply systems in the form of galvanized pipe, and also as a constituent of brass pipe.

In order to determine what effect alkaline waters might have on the zinc in brass, and to study the general effect of pH on the corrosion of brass, a series of experiments on brass pipe (60 per cent. copper and 40 per cent. zinc) in water of pH 6.0 to 11.0 was carried on in the Laboratory of Sanitary Engineering at Harvard. Uniform sections of the pipe with surface of 20 sq. in. were placed in jars with ground glass covers, containing Cambridge water (normal pH 8.0) adjusted with hydrochloric acid or sodium carbonate to the following pH values: 6.0, 7.0, 8.0, 8.5, 9.0, 9.5, 10.0, 10.5, 11.0. Two waters of each pH were made up. In the higher pH range, this resulted in precipitation of calcium carbonate, which was permitted to take place before inserting the pipe. This allowed the solution to have free access to the pipe. One set was allowed to stand 60 days, the other 120 days, in a room maintained at a constant temperature of 25° C. All jars were shaken daily to reaërate the water and ensure uniform oxygen concentration.

It was already known that these solutions, depending only on carbonate equilibria for buffering, would not maintain constant pH. Therefore, periodic testing and readjustment with acid or carbonate was carried on. By this method the pH values were maintained within 0.2 of a unit. This is a tedious and time-consuming method, but no other seems to be available in experiments of this type. Sealed tubes, containing the same mixtures, do not maintain the original pH, but seem to be affected by the course of the corrosion reactions. Other and more stable buffer systems,

*Instructor in Sanitary Chemistry, Harvard Engineering School, Cambridge, Mass.

such as phosphate mixtures, would complicate results by the introduction of precipitates and coatings which would not be found in natural waters.

After the allotted time, the pieces of pipe were removed, and brushed into the solutions, so that any coating might also appear in the analysis. The solutions were then acidified. The method used for analysis of the solutions was a modification of that designed by Fairhall and Richardson[1] for zinc in biological material. It consisted essentially of preliminary precipitation of copper and zinc as sulfides, re-solution of the precipitate and separation of the copper as sulphide, the zinc remaining in the solution. The copper sulphide was then dissolved and the copper determined colorimetrically with potassium sulphide, as in Standard Methods. The zinc was determined nephelometrically as the ferrocyanide. This method proved very satisfactory. It was at least equal to electrolysis for copper, and very good for zinc. The determination of zinc in small quantities is exceptionally difficult, as it forms no colored salts. Experiments with known solutions indicated that the probable error is not over 10 per cent. Duplicate determinations were made. The results were corrected for the amounts of metals removed in the periodic pH tests. The correction was in the neighborhood of 10 per cent. or less of the amount found. The initial volume was 1 500 cc., the final 1 300 cc. for the 60 day tests, and 1 200 cc. for the 120 day. Results are shown in the accompanying table.

Perhaps the most striking result is the tremendous variation in the amount of zinc dissolved. In the case of the 120-day exposure, for example, we find 215 m.g. at pH 6.0 and 1.4 m.g. at 10.0. A definite minimum with respect to solution of zinc is shown to exist at pH 10.0. A minimum point is to be expected with a metal of this type, which is readily attacked by both acids and alkalies. This point coincides approximately with the point of maximum solution of copper. The amount of copper dissolved, however, is small in any case.

If the results are plotted logarithmically, as in the accompanying figure, that is, logarithm of the amount dissolved against pH, a clear picture of the behavior of the two metals is obtained. The logarithm of the amount of zinc dissolved declines roughly as a straight line with increase of pH, to pH 9.5. At this point, the rate of decline diminishes, and a minimum is reached at 10.0. Beyond 10.0 there is a slow rise in amount dissolved. The amount of copper dissolved drops from 6.0 to a minimum at 7.0, then rises to a maximum at 9.5 to 10.0. Beyond this point it falls slightly. With the exception of pH 6.0, the amount of copper dissolved seems to be inversely related to the amount of zinc, that is, as less zinc is dissolved more copper is dissolved and *vice versa*. This phenomenon may be readily explained by the electrochemical theory of corrosion, which may be expressed by the following equations:

$$Zn + 2H^{+} = Zn^{++} = 2H \text{ (atomic)}$$

[1] Fairhall, L. T. and Richardson, J. R., The Nephelometric Analysis of Zinc. Jour.Am. Chemical Soc. 52, 938 (1930).

The atomic hydrogen must then be discharged by one of two methods:

1. by dissolved oxygen: $2H + \frac{1}{2} O_2 = H_2 O$
2. by evolution as molecular hydrogen: $2H = H_2$

For a more complete account of the theory, the reader is referred to Speller, Corrosion Causes and Prevention (1926), p. 21 and following.

Speller (pp. 29–32) shows that when two metals are in contact, the hydrogen film is formed by the solution of the more anodic element, and the solution of the cathodic element is prevented, as would be expected from the relative position of the two metals in the electrochemical series. In the case of brass, zinc is the anodic element, copper the cathodic. The solution of zinc protects the copper from attack. The protective effect on the copper would diminish as the solution of zinc diminished, and thus somewhat more copper would be dissolved. In the case of pH 6.0, it may be that the limit of this protective effect has already been reached, and the greater amount of copper dissolved at 6.0 than at 7.0 merely reflects the increase in hydrogen-ion concentration.

A study of results at the same pH with respect to time may be expected to give some information on protective action other than that just discussed, such as the formation of films of the hydroxides or carbonates of the dissolved metals. If solution after 120 days is less than twice that of 60 days, we may infer that some sort of protective layer is exerting an appreciable influence on the rate of corrosion. The ratio of the amount dissolved in 120 days to that at 60 days will be found in the table. In the case of zinc we can by inspection of the ratios roughly delimit three separate zones, one from pH 6.0 to 7.5 or 8.0, in which such coatings are of slight or no influence because of too great acidity, one from 7.5 or 8.0 to about 9.5, where they exert a generally appreciable influence, and one from 9.5 on, where they are again of slight influence. In this latter zone, according to our theory, coatings of zinc hydroxide or carbonate would be dissolved to a greater or less extent as zincates by the highly alkaline medium. More data would be required to delimit these zones exactly.

In the case of copper, protective coatings generally seem to exert more influence the higher the pH. This might be expected, as copper does not readily form soluble compounds analogous to the zincates, even in quite alkaline solutions. Thus there is no tendency to dissolve any hydroxide or carbonate film at higher pH values. In very alkaline solutions, however, this might not be true. The very high ratio for pH 8.0 is probably due to error.

The practical implications of the experiment may be disposed of as follows. For brass piping, at pH values up to 10.0, the higher the pH, in general, the better the service to be expected, as dezincification will take place less readily at higher pH values. Possibly over long periods, pH values from 8.0 to 9.0 may give as good results as pH 10.0, because of the formation of protective films. Solution of copper from brass seems to be negligible from a service standpoint throughout the pH range studied.

Of course, all deductions are purely relative, and do not imply that brass would be essentially unsatisfactory at lower or higher pH values than the ones cited as best.

*Summary.* The results may be summarized as follows:

1. Dezincification of brass appears to decline from pH 6.0 to a minimum at pH 10.0, and then to rise slightly to pH 11.0.

2. Solution of copper from brass appears to depend on the amount of zinc dissolved, minimum zinc dissolved coinciding with maximum copper dissolved.

3. Protective films retard dezincification only in a limited range — about pH 7.5 to 9.5.

This experiment might be taken as a confirmation of the theory of the existence of minimum corrosion points for amphoteric metals such as zinc. It seems to indicate that the investigation and location of such points for pure zinc, or zinc coatings on other metals, and for the other amphoteric metals might yield results of practical interest. Similar studies on copper and other brasses might also be of value.

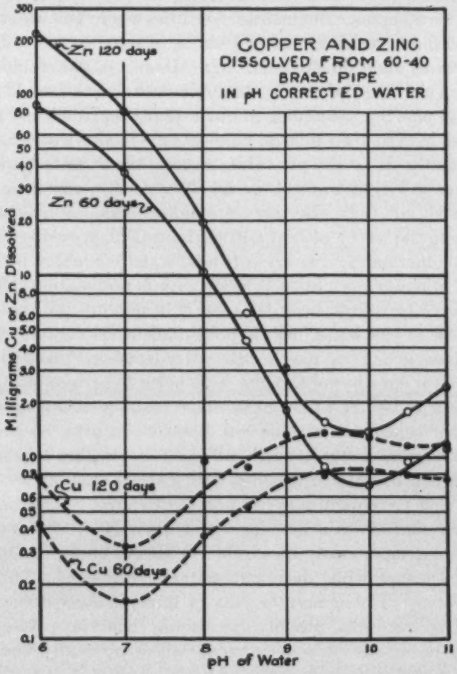
RELATIVE AMOUNTS OF COPPER AND ZINC DISSOLVED FROM 60–40 BRASS IN pH — CORRECTED WATER.
Exposed Surface Area 20 sq. in.

| pH. | Copper — m.g. | | | Zinc — m.g. | | |
|---|---|---|---|---|---|---|
| | 60 days. | 120 days. | Ratio of (3) : (2) | 60 days. | 120 days. | Ratio of (6) : (5) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 6.0 | .43 | .78 | 1.8 | 86.4 | 217.4 | 2.5 |
| 7.0 | .16 | .32 | 2.0 | 37.3 | 82.2 | 2.2 |
| 8.0 | .37 | .94 | 2.5 | 10.7 | 19.5 | 1.8 |
| 8.5 | .53 | .89 | 1.7 | 4.4 | 6.3 | 1.4 |
| 9.0 | .75 | 1.34 | 1.8 | 1.8 | 3.1 | 1.7 |
| 9.5 | .80 | 1.35 | 1.7 | .88 | 1.56 | 1.8 |
| 10.0 | .85 | 1.28 | 1.5 | .69 | 1.38 | 2.0 |
| 10.5 | .80 | 1.13 | 1.4 | .94 | 1.77 | 1.9 |
| 11.0 | .75 | 1.12 | 1.5 | 1.10 | 2.40 | 2.2 |

An excellent paper on the corrosion of commercially pure zinc in waters of different pH has recently been published by Boetheli, Cox and Littreal.[1] A comparison of the data given in this paper with their results is interesting. As plotted in their paper, their figures for corrosion of zinc yield a curve of much the same shape as the author's curve for zinc dissolved from brass. Their minimum corrosion zone is flatter, extending from pH 10.0 to 12.0. They also assign a wide range of stability to hydroxide

[1] Boetheli, Cox, and Littreal — Effect of pH on Corrosion Rate of Zinc in Oxygenated Solutions. Metals and Alloys 3,73 (1932).

films, pH 6.0 to 12.0. These, however, are minor differences. They may be due to the different nature of the materials tested, or to differences in experimental technique. Boetheli, Cox, and Littreal removed $CO_2$ from their solutions by aëration, and their experiments were much shorter than those reported in this paper. The flat minimum corrosion range shown in their results might possibly be explained by the fact that the amount of corrosion




was determined by weighing the test piece. This procedure does not lend itself to the determination of the small differences (one milligram or less) which the author finds in the range 10.0 to 11.0.[1]

No matter how the minor differences between the two curves are explained, it is apparent from their general shape that the solution of zinc from 60–40 brass is affected by pH in much the same way as its solution from commercially pure zinc. The solution of zinc from a galvanized surface may be reasonably expected to show a similar variation with pH. To check this conclusion, experiments with galvanized pipe will be made subsequently.

[1] See Cournot and Chaussain. Comptes Rendus 194,1823 (1932).

## Discussion.

F. G. Smith.* There are some conclusions in this paper which, according to the experience of the American Brass Company during the last ten years, may not always actually work out in practice. We know that in some localities where certain types of water are treated with lime to reduce corrosiveness and the pH is held at about eight, the treated waters are not very corrosive to 60–40 brass. But in other localities where the water is different, the same treatment resulting in a pH value, of say 8.5 or 9, will not reduce the corrosiveness upon 60–40 brass. Mr. Moore's paper would lead one to believe that a pH value of nine to ten in domestic water would give protection for 60–40 pipe but, according to our experience, this is not always true.

We have learned that mineral constituents in the water have as much bearing on corrosion as the pH value because those waters which are not very corrosive to yellow brass of the 60–40 type not only have a pH value of about seven, but they also carry enough calcium or magnesium bicarbonate to keep the water neutral and perhaps in themselves afford protection. On the other hand, if a very soft acid water is treated by adding lime to the point where phenophthalein alkalinity is noticeable, that water becomes corrosive to yellow brass because it is alkaline. Where there is no carbon dioxide in the water, no phenolphthalein alkalinity, and the temporary hardness is not too low, in other words, where the water is neither acid with carbon dioxide nor alkaline with normal carbonates, that water is not corrosive and the pH will be somewhere near seven but not nine or ten.

The other types of brass like red brass containing 85 per cent. copper, or pure copper, are not much affected by waters which are either acid with carbon dioxide or alkaline with normal carbonates.

I think that the conclusions reached by Mr. Moore lead one to believe a pH value of nine or ten is best for water where 60–40 brass pipe is used. According to our experience, this would not always be so, and one would be lost without knowing what the other characteristics are.

Mr. Moore. The concentrations of mineral constituents in waters certainly affect corrosion, possibly even more than the pH of the waters. That is why no anions or cations except those normally observed in all waters were added in adjusting the pH.

Mr. Smith. I know of certain cases where waters that are soft and acid, for example waters from swampy land very low in carbon dioxide but acid and corrosive, if treated with lime to the point where the pH value is nine still remain corrosive. Changing the pH value is not the whole remedy. Other factors must be considered along with the pH. I only know what those factors are through ten or twelve years' experience in handling brass pipe problems from all parts of the country and correlating corrosion data with water analyses.

E. L. Bean.† I think that Mr. Smith has hit on a point which was per-

*American Brass Co., Waterbury, Conn. †Chemist, Water Purification Works, Providence, R. I.

haps overlooked in the original paper, namely, the effect of concentration of anions and cations on solution, rather than the simple question of hydroxyl concentration. The concentration of these other metals will depress the point of the minimum solution of zinc in actual practice. I know from experience that, in a water which tallies somewhat with those described by Mr. Smith, an increase of the pH above eight, approximately, does increase the amount of solution of the zinc.

Possibly another thing besides the concentration of the metals is the concentration of the organic materials in the water, which has a tendency to protect zinc coatings.

PETER P. KOSTING.* In connection with the corrosion of brass, it has been explained that the brass goes into solution. Then you have no longer brass but copper and zinc ions. Something happens. There is a certain type of corrosion which leads to reprecipitation of the copper, which will explain the fact that at the lower pH values the copper content was found to be very low, whereas the zinc content of the water was found to be high. I was going to suggest a microscopic examination of the surfaces, but I don't know whether 60 or 120 days would be sufficient time to allow corrosion to become visible. The point I want to raise is, analyzing the solution for its metallic content after the copper has had the opportunity to reprecipitate, and in cases of high pH where the zinc hydroxide and copper hydroxide have had an opportunity to be precipitated, to judge the corrosion by the amount of zinc in the solution is not practicable.

MR. MOORE. The surface of the pieces exposed to pH 6 and 7 showed a color more like that of copper than of brass. This might indicate either a redeposition of copper or merely solution of zinc, leaving copper behind. If any zinc or copper hydroxide was precipitated on the metal, it was probably returned to the solution by vigorous brushing of the pieces as they were removed. That in the solution itself was, of course, dissolved when the solutions were acidified for analysis.

DAVID A. HEFFERNAN.† The subject, Corrosion of Brass Pipe, has been discussed in this Association for a great many years. The knowledge I have obtained at these meetings and from my own practical experience and observations makes me realize that soil corrosion has to be considered in the discussion of this troublesome problem. Soil corrosion of underground pipes is caused by chemicals in the soil and ground water. It cannot take place in the absence of moisture. Temperature, soil characteristics, conductivity and stray electric currents all affect the rate of corrosion. Electrolysis may occur between any two pipes laid in moist earth if these pipes include two or more different metals, or if there is other potential or electric conductivity. The grounding of electrical currents on water pipes and the possibility of damage through the increase in voltage, careless workmanship and inspection also add to the danger of corrosion.

I should like to know if there is a demand for 60–40 brass pipe now.

*Watertown Arsenal, Watertown, Mass. †Superintendent, Milton, Mass.

My reason for this question is that water-works men feel that by increasing the copper content to say 85–15 it would probably reduce the disintegration of the metal.

We all appreciate the efforts of Mr. Moore to correct the evil of corrosion of brass in water subjected to pH correction, but I doubt very much if he can get the desired results from laboratory tests because I believe other elements besides the water and material are factors in corrosion of brass. On continuing his tests I hope he will use 85–15 pipe.

MR. SMITH. Regardless of how much 60–40 brass pipe may be made I do not believe that many water-works superintendents use it for services. It certainly is not recommended for that use by the American Brass Company. In fact, the American Brass Company does not make this grade of pipe containing 60 per cent. copper, 40 per cent. zinc. Furthermore, we have learned from experience that yellow brass pipe is not suitable for water services as it may fail underground principally on account of stresses due to settling of the soil. For the past nine years we have been recommending and selling red brass pipe containing 85 per cent. copper, which Mr. Heffernan spoke of, and it is very satisfactory. At the present time, more pure copper is used for services than red brass.

Digressing a moment from the subject of the paper I will reply to Mr. Heffernan to say a word about electrolysis or galvanic action. So far as the experience of the American Brass Company is concerned, the small differences in the composition between the pipe and the fittings do not have very much effect on corrosion. Oftentimes pipes will leak at joints and it will be found that the fittings are made of high copper alloy and the pipe of a low copper alloy and then someone says "Electrolysis." As a matter of fact, if the fittings had been made of the same kind of metal as the pipe, the joint would probably have looked just the same. If you are a maker of brass pipe and sell it everywhere, you hear these stories. After many investigations you finally come to the conclusion that about half of what you hear is right and the other half you or no one else can explain satisfactorily.

Usually when pipes leak at threaded joints and electrolysis or galvanic action is blamed for the difficulty, the real trouble is due to the workmanship with which the line was put together. For example, we know in one location pipe of a certain kind carelessly assembled is in trouble in a relatively short time, whereas another installation by a good plumber is satisfactory after eight or ten years. The difference in the performance is not in the pipe or combination of pipe and fittings. It is due to the way the workman assembled the pipe. Such troubles crop up and electrolysis is blamed. I do not believe that electrolysis has very much effect. Theoretically, it has an effect but practically it is not so much as a great many think; at least our experience leads to that conclusion.

GORDON M. FAIR.* Mr. Moore's purpose, apparently, was to determine whether raising the pH of public water supplies had a detrimental

*Assoc. Professor, Harvard University, Cambridge, Mass.

effect upon brass pipe. It stands to reason that no one will go to the expense of applying corrective chemical treatment unless prior experience indicates that the pipe in the system is corroding; and if so, the question is, will corrective treatment improve conditions or will it make them worse. Apparently it will improve conditions in most cases. There are a great many ways in which corrective treatment may be obtained. Corrective chemicals can be added in the form of sodium carbonate, or in the form of lime; the two chemicals will act very differently. While both will raise the pH value of the water sodium carbonate will do so without forming deposit coatings, while lime may at the same time lead to the formation of deposit coatings. These deposit coatings in themselves may be the protective agencies rather than the higher pH values. Has anyone had experience with corrective treatment in which it is indicated that higher pH values increase the corrosion of brass rather than decreasing it.

MR. BEAN. I know of a certain water where that does happen; corrosion of zinc is increased by increasing the pH. In this case however, the increase of pH value produces a reduction in the corrosion of iron to such an extent as to make the increase in pH desirable, in spite of the fact that it results in increased corrosion of zinc.

E. SHERMAN CHASE.* The town of Falmouth for the last two or three years has been correcting the corrosive quality of its water supply, using lime. Prior to the full-scale application of the lime to the supply certain laboratory tests were run using pure iron wire as the control. These tests were made to bring about an accelerated effect of the corrosive water upon the iron. It was shown by the tests that if the pH was raised with soda ash above, I think, pH 9, the iron was corroded almost as fast as at the lower pH values. The laboratory tests indicated a distinct optimum pH at which the corrosion of the pure iron was at a minimum. In practice in Falmouth it has been customary, with the use of ordinary hydrated lime, to get a residual pH of 8.8 to 9. While this practice has not entirely overcome the corrosive effect of the Famouth water it has very materially reduced it.

HARRY W. CLARK.† I think that the paper is a mighty good paper on pure chemistry, but when you put pipes in solutions you sometimes get very different results in regard to corrosion than you do when working with pipes of copper or brass, with water on the inside of the pipe only.

The pH does have some effect, of course, on preventing or controlling corrosion—a considerable effect; but in a paper that I read before this Association in 1927 I stated, as some others have also stated, that pH was not the only thing; that certain constituents of the water also had a good deal of effect upon preventing or accelerating corrosion.

I have had personal experience with galvanic action or electrolysis in my own house within the past two years. I have had brass pipes in use for twenty-two years and never had any corrosion worth mentioning. Two

*Of Metcalf and Eddy, Boston, Mass. †Consulting Chemist, Boston, Mass.

years ago I put in an electric radio that was grounded on a pipe in the basement. Almost immediately I began to have blue-green deposits in the tubs and also in the set bowls in the bath-rooms. I was a little puzzled for a while in regard to this, not thinking of the electric radio, but on moving the grounding to a different place the blue coloration disappeared. It may have been something else you know that caused the corrosion but I laid it to the radio.

MR. HEFFERNAN. I received a letter last week from an official of a private water company located just outside of New York drawing my attention to the following facts. Blue water found in a bathtub was traced to a radio grounded twenty feet inside of the water meter. The blue, which apparently was caused by slightly disintegrated brass pipe, disappeared when the ground wire was moved to a different point. As Mr. Clark says, you can make all the studies you want in the laboratory but you will not get definite results with all the conditions that are causing the corrosion of the pipe.

Today the water-works superintendents are somewhat puzzled about the choice of material to use for service work that will be immune from all objectionable conditions. Galvanized wrought-iron and steel pipe lined and coated both inside and outside by dipping in a bath of molten zinc is the most commonly used form of metallic coating. The threads which are usually cut after galvanizing expose the bare iron to corrosive action of the water; galvanic currents passing from zinc to iron remove the zinc at the threads exposing large surfaces of iron to corrosive action. Copper and red brass pipes are used by many communities and from all reports are giving perfect satisfaction. I still doubt the permanent adoption of these materials for services underground. The objections being the discoloration of water caused probably by soil corrosion, galvanic action, electrolytic action, and grounding of wires.

MR. CLARK. I think you will get just as good results with copper pipe as with brass pipe.

MR. HEFFERNAN. I do not approve of either one underground. I am of the opinion that iron-sized brass pipe is the best to use inside the building. If you want to avoid some of these annoying elements in service pipes, especially the discoloration by blue or green water, use wrought-iron cement-lined pipe with special lined fittings. It should not be forgotten to line the curb cock at the sidewalk. This is the method used in Milton and it gives general satisfaction.

MR. CLARK. I think they both, brass or copper, and cement-lined pipes have their place. In the last few years all our experiments on corrosion have been done with pipes set up as service pipes,—copper, brass, lead, or whatnot—because in the old days when we used to immerse them, sometimes we would get very reasonable results and sometimes very unreasonable results.

I believe that Mr. Heffernan will, one of these days, perhaps, put in a brass pipe, or a copper pipe, and see that it works all right.

MR. SMITH. To answer Professor Fair's question, he knows that in Baltimore the water is filtered, treated with lime to reduce its corrosiveness. Very good results are obtained, the pH being adjusted at about eight, I believe. As far as I know, this treated water is not actually very corrosive. I do not know exactly the type of water which they treat but it has an important bearing on the results obtained. There is a small filter plant at Hampton, Va., where water is taken from a reservoir the basin of which, I understand, was originally a bog or marsh. The water was found to be acid and corrosive, and it was treated with lime until the pH was brought up to about nine, but the corrosion was not stopped. I believe that this is because this very soft water treated with lime is actually alkaline with normal carbonates; even though the pH value has been raised, the water is corrosive toward the cheaper grades of brass pipe. It appears from these two examples that different types of water cannot be treated in the same manner to raise the pH value to a high point with the result that corrosiveness is always reduced.

MR. FAIR. I have never believed that the solution of the corrosion problem lay alone in the increase of the pH to decrease the solution of the metal. It has always been my opinion that Nature's most important way to decrease corrosion is to form a protective coating on the metal. The purpose of artificial treatment may, therefore, well be such that a protective coating will be formed. If it is not formed there may be solution of the metal. In line with this reasoning I am more favorable to the use of lime rather than soda ash, because lime does, under proper circumstances, form protective coatings. A cement lining in a pipe is a form of protective coating. There may be situations where no reasonable kind of chemical treatment will form a protective coating. There we have to resort to protective coatings in the form of cement linings.

As to the difficulty of interpreting laboratory studies, such as Mr. Moore's, in the light of experience, it is my belief that theory must go hand in hand with practice if we are to arrive at a broad solution of this rising problem of corrosion. Pure chemistry has its place in this scheme as well as pure empiricisms. In the long run theory will explain what practice finds to be true.

MR. MOORE. The discussion of the author's paper has clearly shown the difficulties of applying information on corrosion obtained in the laboratory to the phenomena of corrosion under service conditions. In the latter case, the extent of corrosion is determined by a great many factors, among which are the mineral content and dissolved oxygen content of the water, the presence or absence of protective coatings, and the influence of stray electric currents. These factors may also vary from time to time within a given system. Therefore the laboratory worker's possible service is limited to the determination of the quantitative effect of one or the other of these factors when all the rest are held constant. He cannot decide with any certainty whether a water will or will not be seriously corrosive. He can only

state under what circumstances its corrosive power will be reduced or augmented.

The purpose of the paper was an attempt to show what happens to brass when the pH alone varies and all other factors are held constant, or eliminated. The deductions drawn are therefore strictly relative to the known behavior of any water to which they are applied. For example, if a water is highly corrosive to begin with, the reduction in corrosion obtained by merely raising the pH may be entirely negligible from a service standpoint. Another water may be so kind to the piping which carries it, that there is no point in raising the pH.

The case cited by Mr. Bean makes it evident that the minimum corrosion point for zinc is not always at pH 10.0. In that case it was evidently at or near eight. If the author's tests had continued for a long time, it is possible that a pH of 8.0 or 9.0 might show as good or better results than pH 10.0 by virtue of the greater stability of the protective coatings of zinc compounds at the lower pH values. This fact was stated at the time the paper was presented.

# A HISTORY OF WATER SERVICE INSTALLATION IN NEWTON.

BY MICHAEL J. HERLIHY.*

[*Read December 13, 1933.*]

The beginning of the Newton Water Department dates back to the early part of 1876, at the end of which year, there had been installed 496 services. At the present time, there have been installed some 15 000 services. During the fifty-six year interval in which the Department has been engaged in supplying water to its consumers, it has had some varied experiences with different types of service pipes.

In the early years the practice of using black iron pipe for services was followed. The sizes used were ¾, 1½ and 2 in. and a tap one size smaller than the pipe was employed on all except the 2 in. services on which it was the practice to utilize a ⅝-in and 1-in. tap, yoked. All taps were connected to the service pipe by a lead gooseneck of the same size as the tap.

Later the use of black iron pipe was abandoned and lead pipe was substituted, the sizes selected being, ⅝, ¾ and 1 in. The Department reserved the right to specify the kind and size of pipe to be used although sometimes the Department gave way to the owner and allowed him to buy and lay his own pipe from the street line to the cellar. In later years, if the owner insisted on laying his own pipe, a meter was installed in a box at the street line, on end of the pipe laid by the Department. Today the Department furnishes and lays the pipe and sets a meter in the cellar in all cases except where there is no cellar under the building. Then the meter is set in a meter box at the street line.

A large percentage of the houses during the early history of the Department did not have any heat in the basement, and a great many services were laid through the wall and under the cellar floor which frequently had only a dirt surface. Hence when the meters were set, it was customary to bury them under the floor in a small box. This resulted in a poor setting from two standpoints: (1) it was not simple to replace the meter for any reason; and (2) considerable difficulty was experienced in reading meters so placed, as wood and other materials generally found their way to that point.

The use of lead pipe was continued until about 1900, when presumably due to the number of leaks occurring in lead services, this practice was dropped and the Department then changed to 1-, 1½- and 2-in. galvanized wrought-iron pipe as a standard. One-inch taps and goosenecks were used to connect to the 1-in. services. One and one-half-inch taps and rigid connections were used on 1½-in. services. The 2-in. services were fed by two

*Foreman, Water Department, Newton, Mass.

taps, a 1½-in. and a 1-in. tap. The larger of these taps was connected by a rigid connection to the service pipe while the smaller was connected by a 1-in. gooseneck to a 2-in. by 1-in. tee.

During the period between 1910 and 1919 the Department experienced a great deal of trouble with the splitting of lead goosenecks. In 1919 the Department was using a 1-in. Corporation cock with a female outlet. It was decided then to make rigid connections to the taps, replacing the gooseneck by a 1-in. galvanized nipple and a 1-in. union and to lay the pipe on solid ground to the cellar. The Department was very careful in the preparation of the foundation for the pipes and insisted on building up under all couplings and fittings and using great care in back-filling and packing under the pipes so as to have no strain on them. This practice was felt necessary to insure the success of a rigid connection, as had been learned by experience since 1900 on 1½-in. service installations.

From this time on the Department steadfastly refused to permit any other utility to lay pipes within four feet of the water-service pipe. Where a sewer connection must be laid in close proximity to the water pipe the sewer must be laid first and the sewer trench widened from a point not less than 4½ ft. below the surface to form a shelf of solid material. On this shelf the Water Department will lay its pipe. Lead goose-neck connections were no longer used except in swampy or wet ground and wherever required in the repair of old installations.

The Department wherever possible required that the service pipe be entered through the foundation above the cellar floor, so as to be able to make a proper meter setting. Also in case of corrosion at the tap or the curb cock, this practice permits of the clearing of the service and eliminates the cost of digging up either the basement floor or the street. In cases where insufficient cover existed over pipe at the grade outside the cellar wall the pipe was brought in under the cellar floor, then up a distance of six inches above the floor.

Although the Department felt that it had a fairly good service installation at this time, a weakness developed, in that the 1-in. galvanized nipple corroded at the threads where it was screwed into the tap thus causing leakage. The same thing happened at the curb cock which at that time had female outlets. Therefore a heavy copper nipple was substituted at the tap and one was used on each side of the curb cock. This practice worked out very well but the objection was offered that the use of three different metals in close proximity one to each other might induce galvanic action. While our experience has since lead us to question the seriousness of any damage which might result from such action between dissimilar metals, the Department about 1925 adopted a corporation cock using a union tail piece of the same metal as the cock body and also curb cocks with male outlets.

In 1929 the Department made its next change in service pipe practice, changing from galvanized to cement-lined wrought-iron pipe with lead-

lined fittings. It was decided to use only two sizes: 1¼ and 2 in. This decision the Department arrived at after taking into consideration the type of residences being built in Newton, the set backs ordinarily established and types of plumbing fixtures being installed. Newton is zoned in such a manner that 92 per cent. of the city is reserved for residential property, and the usual set backs are not less than 30 ft. Within the last few years most of the properties constructed have had two or more full baths, and in a great many cases flushometers have been installed. The demand resultant from the construction of properties of this kind is for a large volume of water in a limited period of time and it was deemed wise to reduce as much as possible the friction losses in the service pipes.

The method of installing services up until 1931 was to take sufficient pipe to the job and there to cut, thread and fabricate the line to meet the requirements. This practice proved more or less unsatisfactory inasmuch as considerable difficulty was experienced in keeping the tools and dies sharp. Too frequent recourse was taken to pipe cutters that caused the cement lining to shale off exposing the unlined metal. Each service truck became more or less cluttered with small ends of pipe,—from a few inches to three or four feet in length,—most of which became badly battered and a large proportion of which found its way into the junk pile.

In 1931 the Department's supply yard was rebuilt and there was provided in our remodeled structure an up-to-date pipe shop. Modern pipe-cutting and threading machinery was installed and the service pipe construction methods were again modified.

The present procedure is to attempt to so lay out our service work, that the main to be tapped will be exposed before noon. The chauffeur assigned to cover any particular service installation or installations is required to visit his jobs between 11 A.M. and 12 NOON and to receive from the piper the measurements of the pipe required. These measurements are turned in at the supply building at noon and during the lunch hour the man on duty cuts, threads and fabricates complete the pipe as requisitioned. All couplings and fittings are run up on the threads but are not "put home" until they are in the trench. All pipe is made ready by 1 P.M. for delivery to the different jobs by the chauffeurs. The field piper then has only to put together any long lengths and to fit the pipe into the trench.

This practice assures the use of smooth and evenly cut threads, properly fitted couplings and fittings, takes less time and produces a thoroughly workman-like job. Furthermore the shop man has an opportunity to utilize completely all small pieces of pipe so that all waste is eliminated.

In order to eliminate some breakage of curb cocks which had been experienced where heavy trucks pushed our service boxes down on the fitting, the Department in 1932 adopted a 1-in. curb with heavy 1¼-in. male outlets. This provides a minimum metal thickness of ¼-in.

The Department's records of the last two years show a total of 384 service leaks, or an average of 192 per year. Fifty-eight and one-half

per cent. of these were caused by split lead goosenecks, 11.2 per cent. were caused by corroded 1-in. galvanized nipples at the taps or curb stops, the remaining 30 per cent. of the leaks were due to various other causes.

With approximately 15 000 services in use today the total number of leaks occurring in an average year amounts to 0.64 per cent. This figure we believe will be materially reduced as we gradually replace the gooseneck connections and the 1-in. galvanized nipples at the corporation and curb cocks (which as before stated are responsible for the bulk of our service leakage) and as the proportion of services using rigid connections, now 40 per cent. of the total, increases with our growth.

## Discussion.

Roger W. Esty.* We have been using goosenecks in our service connections for a good many years but have not run into any trouble.

What is the pressure at Newton?

Mr. Herlihy. Our pressure varies. As an average over the whole system it is between 60 and 70 lb. per sq. in. Our greatest pressure is around 135 lb., and it goes down to 35 or 40 lb.

Henry T. Gidley.† I would like to ask Mr. Herlihy what is the weight of the lead used for goosenecks?

Mr. Herlihy. It is 5½ lb. per ft. for 1-in. pipe, and 4½ lb. for ⅝-in.

David A. Heffernan.‡ I think that on a ⅝-in. pipe the weight of lead pipe should be 3 lb. per ft. for good water-works practice. On ¾-in. pipe, to take in all pressures from 40 to 130 lb. per sq. in., it should be 5 lb. On 1-in. pipe I use 6 lb. per ft. and on the 1¼-in pipe 9 lb. per ft.

Mr. Herlihy spoke about having a lot of trouble from split lead pipe. You never can get split pipe with such weights.

Nelson Boardman.§ I would like to ask Mr. Herlihy whether he uses flanged joints on the gooseneck?

Mr. Herlihy. No. It is a special fitting which was devised years ago by one of the men connected with the Newton Water Department.

Mr. Boardman. Is it soldered in?

Mr. Herlihy. It is fitted with a thimble, into the lead.

Mr. Esty. What kind of a connection do you have with the outside meter?

Mr. Herlihy. We have a cement meter box which comes in four sections. When we set the meter we carry it to within a foot of the top of the box, so it is easily set and easily read.

Mr. Heffernan. I do not think that the water-works officials take things seriously enough relative to just what is causing the trouble in their service pipes, or main pipes. There are three elements, in my opinion,

*Superintendent, Danvers, Mass. †FairhavenWater Co., Fairhaven, Mass.
‡Superintendent, Milton, Mass. §Assistant Superintendent, Danvers, Mass.

which I consider important in deciding how we shall connect up our service pipe to the main. These are soil corrosion, galvanic action, and electrolysis.

Soil corrosion: Soil corrosion of underground pipe is caused by action of chemicals in the soil and ground water and cannot take place in the absence of moisture. Temperature, soil characteristics, conductivity, and stray electric currents all affect the rate of corrosion.

Galvanic action: Galvanic corrosion of water pipe is caused by contact between pipes and fittings of different materials, such as clamps, U-bolts, gaskets, corporation cocks, wrought-iron risers on cast-iron services, lead goosenecks, impurities in the metal itself, poor application of metallic coatings, close proximity of pipe lines underground, and use of unsatisfactory materials for back-filling trenches.

Electrolysis: Electrolysis, or electrolytic corrosion, occurs in water pipes when an electric current of external origin—usually stray direct current from the return circuit of a street railway system, or electric power circuit whose rails are not properly bonded—gets into the water pipe. There is also the grounding of wires on house service pipes with alternating current to provide a metallic return circuit for the current, and thus improve the quality of the service without the expense of return wires. These disturbing conditions I honestly believe are not taken seriously enough by water-works men to obtain the best standards in service installation.

Many water departments have abandoned the lead gooseneck in connecting up their services, one of the reasons for doing this, in my opinion, being to eliminate the possibility of leakage at the joints, cup or wiped. From my own experience I believe if the joints are made properly and heavy lead pipe is used, there will be no trouble from this source. Another reason for not using the lead gooseneck is that it does away with the services of the skilled mechanic and permits the substitution of the handy man in his place. The advantage of the lead gooseneck over the rigid joint connection allows a margin of safety for expansion and contraction, settlement of materials, etc.

Conditions in trench excavating are different today than they were twenty years ago. Permanent road construction requires other utilities to locate their pipes in one street opening. I do not approve of this method. But nevertheless it is being done in many places. This means the supporting material under the pipes will be disturbed. With this condition the lead gooseneck with its margin of safety will stand up better than a rigid joint.

That to my mind is a very serious condition. Mr. Herlihy spoke of different services being 4 ft. apart. That requires a pretty wide opening. He also mentioned putting waterpipe on a shelf. That shelf, I suppose, will be about 1 ft. The gas line, I suppose, would be placed on one side on a shelf and the water on the other side. Is that the procedure?

MR. HERLIHY. We generally try to keep as far away from the sewer trench as possible. We insist that we lay our pipe on solid ground right from the main to the cellar.

MR. HEFFERNAN. If your practice could be carried out it would be a very good practice, but we can't do it in Milton. With your good paving the street department will only permit us to make one opening, and the pipe must be placed in that trench on a shelf. If you have a rigid joint and if there is any settlement of the material, there is going to be a strain and something has to go.

There is one thing more I would like to say. Substantiating my remarks relative to electrolysis, it might be of interest to the members to report from the Plumbing and Heating Trade Journal for the month of November, 1933, an interesting article by A. R. McGonegal, Chief Plumbing Inspector, District of Columbia:

> The American Water Works Association, as the only organized representative of the hundreds of municipal and privately owned public water supply systems, gave away something many years ago to which it had no title and in which it had no direct financial interest.
>
> The compilers of the National Electrical Code demonstrated a supposed need for grounding a neutral wire of an electric circuit between the main circuit on the poles and the terminals at the main switch on the customer's premises. It was speciously pointed out that a neutral normally carried no current, and in emergency only a very small potential. Under such circumstances, the grid formed by the public water mains under the streets became an ideal ground for occasional stray currents and, by reason of its grid form and its house-to-house connections, would act not only as a ground, but also as a balance.
>
> Thus, the compilers of the National Electrical Code calmly accepted something that the American Water Works Association had no right to give, and forthwith put it in the draft of the Electrical Code, where it has been ever since, frequently to the detriment of the public water supply distributing systems. Some electric service utilities even went so far as to run bare neutral wires, thus saving cost of insulation, though this practice is forbidden by local rules in a majority of cities.
>
> Now there is a concerted and well-planned movement on foot to extend this questionable practice to electric light and power wiring on the interior of the consumer's premises, placing the burden of carrying any stray or accidental return electric currents on the pipes of the plumbing system, and the master plumber, who is responsible for the integrity of the plumbing system, has been given no voice in the matter.

FRANK S. BRAINARD.* I would like to ask how Mr. Herlihy makes the rigid connection; what fittings are used in the connection.

MR. HERLIHY. Insert a tap in the side of the main with the union tailpiece, which is secured into a fitting. Where we use a 1¼-in. pipe we have a 1¼ by 1-in. fitting, then the pipe from that point is straight into the cellar. There are no other fittings. All couplings are built up, and all fittings are packed very carefully underneath.

MR. GIDLEY. I think Mr. Heffernan brought out some very good points. I think the great trouble in lead pipe and lead goosenecks lies, as he said, in the weight of the pipe. We use for ¾-in. pipe, 4-lb. lead, and about 6 lb. for 1-in. pipe.

He also spoke about the grounding of wires to the waterpipe. That is a thing I think people have not looked into enough but are looking into

*Hartford, Conn.

it now. We ground the telephone, the electric light and the radio on the waterpipe. In certain experiments it is reported that trouble was experienced with colored water in certain sections, and they also had trouble with the taste of the water. They tried a number of experiments, and when they disconnected the radio from the waterpipe the water cleared up, had a good taste and was not colored.

A MEMBER. In my town we have been conducting a series of experiments for grounds. We have been using Leadite or Lead-Hydro-Tite for the last fourteen or fifteen years, and the electric services have practically come to the decision to do away with pipe connections in our town.

EDMUND C. SANDERSON.* I have been in the electrical business for thirty years, and I have followed the grounding pretty carefully. We have never had a case in Winchester where our pipes have been damaged from the alternating current escaping to our system. Alternating current does not cause electrolysis; direct current does. Since we have changed all our street railways we have not had any more trouble from electrolysis.

I think this subject is misunderstood. The grounding of house currents is a safety device and I think it should be practiced. We go so far that when we put in a new service we make a charge of $1.50 to see that the ground cap is properly put back. From our experience we have not had any trouble whatever with it. We use brass pipe and lead pipe, and our old pipe is galvanized iron. We are fortunate enough to have the water and the sewer services in one department. We find it works very well. We always lay the waterpipe with the sewer, in the same trench. Our men are careful in seeing that the waterpipe has a proper footing, and we have never had any trouble with it. We use recess couplings and have practically no service trouble whatever.

MR. BRAINARD. We use a swing or semirigid connection. We have had practically no trouble since we switched to that, and in our opinion we much prefer the semirigid connection which we use to the lead connections which we formerly employed.

MR. HEFFERNAN. Is that on a street L?

MR. BRAINARD. No. On the ordinary corporation cock, screwed into the main, and then the street L. There are two street Ls and the ordinary street L used at the main, making a swing connection there which is not rigid, which would allow for some settlement.

MR. HEFFERNAN. I would like to ask Mr. Herlihy a question: Where do you tap a pipe; at an angle of 45 degrees; on what part of the main?

MR. HERLIHY. Practically the center.

*Chairman, Water Board, Winchester, Mass.

# WATER WORKS PRACTICE AT TAUNTON, MASSACHUSETTS.

BY ARTHUR C. KING.*

[*Read December 18, 1935.*]

It is not the intention of this short paper to hold up the practice of the Taunton Water Works as an ideal or model, but rather to describe what is being done, in the hope that it may be helpful to some member, either directly as an idea to be improved upon, or only by elimination, suggesting something that might better be avoided.

Taunton is a city of only about 37 000 people, but covers an area of 50 sq. miles, being one of the largest cities in the country in order of area. This is of course a disadvantage rather than otherwise to all utilities in the added expense to reach and serve a scattered population. The water system has always been municipally owned since its establishment in 1876. Its management is in the hands of a Board of three Commissioners, serving three-year terms, one member being elected each year by the City Council. The Board organizes by choosing one member as President and a Clerk who is not a member. The Clerk's salary, as well as that of the members of the Board, is fixed by ordinance, but the Board fixes the compensation of all other employees. The Clerk's duties include those usual to the office of Registrar, but not of Superintendent, although it has been customary since early in the history of the works to employ the Clerk also as Superintendent.

The source of water supply is a chain of five connecting natural ponds with a watershed of about 50 sq. miles. These ponds also supply the city of New Bedford. Under Chapter 400 of the Acts of 1924, division of expenses and allotment of water were provided for between New Bedford, Taunton and Fall River, but since that year Fall River's need for additional supply has disappeared. Taunton's allotment is 8 m.g.d., but the average daily consumption has not yet been more than 3¼ m.g.d. and for the last few years has been below 3 m.g.d.

Swimming is forbidden in the ponds from which Taunton and New Bedford draw directly, while boating and fishing are allowed by special permits issued by the two Water Departments. The water is used untreated, and Taunton does not regularly patrol the shores or watershed although in the writer's opinion it would be advisable, in the summer at least. Dependence for purity is placed upon long storage and occasional inspection of conditions near the shores. Water samples are examined by the State Department of Public Health each month. From the largest of the ponds, Lake Assawompset, which has an area of 2 178 acres and an estimated capacity of 2½ billion gallons, water is pumped through a 24-in. cast-iron main about 1½ miles long into Elders Pond, a spring-fed pond

*Superintendent and Clerk, Taunton Water Works, Taunton, Mass.

about 145 acres in area with a capacity of about 692 m.g., from which the water flows by gravity through a 30-in. cast-iron main 7½ miles long to the city.

The pumping is done by a 5-m.g.d. vertical, triple expansion steam engine installed in 1894. Through the summer this pump is normally operated 24 hours per day, six days a week, but in winter only as necessary to keep up the water level in Elders Pond. When the intake water at Assawompset is objectionable due to vegetation or because it is stirred up by a strong east wind across the pond, and also when young herring are seeking the outlet, pumping is discontinued until conditions are favorable. Such periods are used for repairs and overhauling of the pump. Two or three men are constantly employed around the shores and on the watershed mowing, ditching, cleaning intake screens, trimming trees, etc. When regular employees in the city are available they are sent over for a day or more at a time for this work. In winter, if the ice becomes thick, a lane in the ice is cut as often as necessary to keep the ice pressure from damaging the gate houses or the riprap on the intake dikes. Once or twice a year the grass and water plants growing within a quarter mile from the intake are mowed with a submarine saw 50 ft. long and the plants raked from the water. Considerable portions of the land owned on the watershed have been set out with trees, mostly white pines. There is a considerable number of summer cottages around the shores, but most of the owners are ready to coöperate in keeping sanitary conditions satisfactory. If property on the shore comes on the market at a price which can legally be paid it is the practice of the Department to purchase it, and if any owner neglects or refuses to comply with sanitary regulations he is liable to wake up some morning and find that his property has been taken from him.

Entirely around Elders Pond a strip of land 5 rods wide is owned, as well as some much larger tracts on the watershed adjoining. The whole shore, which is sandy, is harrowed and raked to keep down all vegetation.

The 30-in. main from Elders Pond delivers the water at a pressure of about 25 lb. per sq. in. to the distribution pumping station, which is about 1½ miles east of the center of the city. There is no elevated storage, so this station has operated without interruption for 57 years. This of course necessitates duplication of all essential parts. There are three pumps, each of which can take steam from either of two steam lines from the boilers. Two boilers, half banked, are on the line at all times, with a third in reserve, but cold, although one could carry the normal load. While this is not economical it is necessitated by the possibility of large demand for fire fighting at any moment. At every alarm of fire the pump is speeded up a little, to raise the water pressure from 70 lb. per sq. in., the domestic pressure, to 100 lb. per sq. in. fire pressure, or to 105 or 110 lb. for second alarms from certain boxes in higher sections of the city. This changing of pressure is a source of annoyance, or worse, by developing leaks just when

they are least desired, that is, when both volume and pressure are wanted by the firemen.

As an illustration I shall mention a break that occurred in 1932 at 2 o'clock in the morning of St. Patrick's Day. The pressure had been raised for a small fire, a hen coop I believe, on which one stream was playing when suddenly the pressure dropped, and the engineer at the pumping station thought for a moment that the supply line had burst and left him without water. Shortly after, police reported water coming up through the concrete paving on Main St., and after shutting down the 16-in main and opening the pavement, it was found that one length of cast-iron pipe, in use about 56 years, had suddenly cracked nearly its whole length. Pressure could not be maintained in the rest of the system until this section was cut out. Continuous work for 24 hours was necessary to replace this length of pipe and restore the service on one side of Main St.

The main pumping unit is a horizontal cross-compound engine of 10-m.g.d. capacity, installed in 1914. Since that time this pump has done the bulk of the work, as it is economical and very flexible. Its speed can be varied from 46 r.p.m. for fire draft down to 8 or 9 as the consumption falls off in the early morning hours. The other pumps are both horizontal compound engines, one with a capacity of 8 m.g.d. installed in 1901, the other rating 4 m.g.d. installed in 1891. Steam is always in their cylinder jackets keeping them warm ready for use, and each of them is operated for several hours once a week. In case of failure of the supply from Elders Pond, either the 10-m.g.d. or the 4 m.g.d. pump can draw for a few hours from an infiltration gallery at the rear of the station, formerly a source of supply.

From this pumping station two 20-in. mains follow different routes toward the center of the city and the gridiron system. From one of the 20-in. pipes a 16-in. main leads to the north end and a similar 16-in. main leads from the other 20-in. pipe to the south end. Interlocking loops of 12-in. pipe completely surround all built-up sections of the city, with 8-in. secondary feeders within the loops to 6-in. lines. Little 4-in. main is still in use since 1930 when a five-year program of replacement was completed. Twenty-five miles of 8-in. and 12-in. mains were laid in that program, replacing 4-in. and 6-in. mains, many of which had been in use 45 to 55 years. This program cost $435 000 which might have been spread over 25 years instead of 5 if the Water Board had had control of its receipts. Some of the mains taken out had been recommended for replacement at least 20 years before the inauguration of this program. All of the pipe used in the five years was centrifugally cast and cement lined. Fittings were also cement lined.

One man is held responsible for the condition of hydrants. He uses a light truck and upon occasion is given help temporarily, as in very cold weather, for heavy repairs or to speed up the fall preparations for cold weather if it becomes necessary. Every hydrant is operated and tested at least twice a year, in the spring and again in the fall, and during cold

weather it is tested at intervals for dryness to prevent freezing. Denatured alcohol is placed in those hydrants which cannot be kept dry, but if one does freeze it is thawed with lump carbide.

A foreman answers every fire alarm and notes what hydrants are in use so that the hydrant man may check them the following day, and the Fire Department reports any hydrants used when no alarm was sounded.

In summer, hydrants are opened each morning and closed at night for construction work by other departments or by contractors, a valve being placed for their manipulation through the day. Meters are also set with these valves where there is to be any considerable use of water.

Dead ends are flushed regularly in summer, and upon complaint in the winter. It is planned to inaugurate a system of gate inspection next spring.

From the beginning of the works in 1876 until 1927 wrought-iron pipe lined with Rosendale cement by Department employees was used for service pipe, with lead goosenecks. Since then, red brass pipe, iron-pipe size, has been used, connected rigidly to the main with taps made horizontally. The standard is 1-in. throughout, although 1½-in. and 2-in. pipes are also laid of red brass pipe. If a pipe larger than 2 in. is required a 4-in. or 6-in. cast-iron pipe is laid. The Department installs the service from the main into the cellar, charging the owner for the part on his property only, at a standard rate per foot, 50 cents for 1-in, 80 cents for 1½-in, and $1.00 for 2-in. pipe. The Department maintains the service without charge but does not maintain or install the shut-off in the cellar. Meters are paid for by the owner but are maintained free of charge.

The maintenance of the 6 600 services requires the employment of three men with a light truck throughout the year, with extra help for digging. Poor pressure complaints to the number of 500 or 600 per year are largely remedied by wiring; that is, pushing and twisting a heavy wire through the pipe from the cellar, with the water turned on to wash out what is loosened by the wire.

Meter work keeps six men busy, two men with a truck taking out and resetting meters, two repairing meters and two reading them. Every meter is cleaned and tested at least once in four years. Even though a meter shows no indication of anything wrong, if it has been in service without a test for four years it is brought in, tested, cleaned, repaired if necessary, and tested again, and made to register between 98 and 100 per cent. on three or more different sized streams, according to the size of the meter. The smallest stream regularly used is ⅛ in. Meters are read once in about five weeks, although three in heavy use are read weekly. When the domestic bills are being made, in June and December, all of the meter department except the man in charge, five in number, read for two weeks or more to cover the whole system as quickly as possible. The regular meter readers, when not doubling back to cover "outs," average about 120 readings per

day. Upon complaint of large bills, fixtures are examined for leakage without charge.

As was mentioned earlier in this paper, the duties of the Clerk of the Board include those commonly taken care of by the Registrar; that is, the accounting of the Department, also billing and collecting. Receipts are turned over to the City Treasurer, and all bills and payrolls of the Department are paid by him after approval by the Board.

Operating funds are appropriated by the City Council, as they are for other departments. There are no complete bookkeeping or cost account systems as the office force has been kept at a minimum. In addition to the Clerk of the Board, who is also Superintendent, there are three office clerks who subtract the meter readings, make out the bills, post the receipts, and keep up the usual office work. Domestic consumption is billed semi-annually, business quarterly. An Addressograph is used, but aside from that the bills are made out by hand, as well as the postal card notices which are mailed, the bill and cashier's stub remaining in the office until paid.

While the meter readings are being subtracted in the office after each reading, whenever an unusually large use is noticed, unless a reason is indicated, a postal card notice of increased consumption is sent to the owner as a warning of possible leaks unknown to him. Also, if the reader has been unable to get in for three consecutive months to read the meter, a card is sent to the owner asking that arrangements be made for the reading to be secured. A ledger card is used for each service pipe. This is a change made recently from the use of a book in the hope of purchasing a billing machine before long, with which the cards would be needed. The card system entails a little more work now by hand, but will save a great deal when employed in connection with the machine.

When a water bill remains unpaid after twenty days, a second notice is sent which brings in quite a number of people. Although the lien law has been accepted by the city, it has not yet been used. Occasionally water is shut off on account of non-payment of bills, but chief dependence is placed upon personal insistence. This is one feature of the customary procedure in Taunton which I wish to emphasize as one to be avoided. I believe that nearly all can pay their water bill as they should with reasonable promptness, and they will do so if an inflexible system is used, always shutting off the water after a definite time for payment has passed. If people realize that service actually will be discontinued the money will be forthcoming. Without strict adherence to such practice, the same people will again and again neglect or put off payment of every bill as it comes along. Of course this does not apply completely under the conditions of the past two years. Anyone who has come in and said he was unable to pay from lack of work has been urged to bring in any amount, even 50 cents or $1 when he could, and it is credited to him. A great many have taken advantage of the offer and appreciated the accommodation.

For unemployment relief the City Council has made three special appropriations by bond issues, amounting to $30 000, with which the Water Department has laid about 4½ miles of 6-in. main extending into outlying districts where the volume of business is too small for extensions to be made on the regular guarantee basis of $20 a year income from each 100 ft. of extension. In this work, pipe was laid that had been taken out in the five-year program previously mentioned, so that most of the expenditure was for labor. During spare time, regular employees have cleaned and sand-blasted the pipe and spray painted it with bitumastic paint, ready for use. The $30 000 has not been entirely spent, but this week two projects were started with C.W.A. funds, laying nearly a mile more of the 6-in. pipe. The pipe is to be laid by regular employees on the regular payroll, but the digging is being done by laborers on the C.W.A. payroll.

## DISCUSSION.

ROGER W. ESTY.* I would like to ask Mr. King to explain in more detail how he thaws out hydrants.

MR. KING. In cold weather the hydrant man carries a little lump of carbide, the same as we use in a carbide lamp. He breaks off a lump that will pass the nozzle of the hydrant, and the carbide will bore a hole through the ice in a few minutes. Then he can turn the water on in the hydrant and wash out the rest of the ice. It is much handier than trying to get hot water or steam into the hydrant.

MR. ESTY. Suppose you had a hydrant frozen from the top right down to the base. How long would it take to thaw it out and would it take more than one lump of carbide?

MR. KING. It probably would take several lumps. We do not often have them freeze as much as that.

*Superintendent, Danvers, Mass.

# RESULTS OF WATER WASTE SURVEY IN LEXINGTON, MASSACHUSETTS.

BY A. A. ROSS.*

[*Read December 13, 1933.*]

The Town of Lexington receives its water supply from the Metropolitan District Commission. The water is supplied by gravity from a standpipe located on Arlington Heights and flows through a 16-in. cast-iron main to the Metropolitan Venturi meter in Massachusetts Avenue at the Lexington-Arlington line. At this point the water enters a 16-in. Lexington trunk main, which extends for a distance of approximately 3 miles to the standpipe.

There are approximately 69 miles of mains in the distribution system. All the mains are cast iron, varying in size from 4 to 16 in., with a very small amount of 4-in. pipe. A concrete standpipe 105 ft. high and 30 ft. in diameter with a capacity of 550 000 gal. is connected with the system. The population supplied is approximately 11 000.

In the fall of 1931 an investigation was made of the consumption of water as recorded by domestic and industrial meters. This investigation disclosed that only 53½ per cent. of the total consumption as recorded by the Metropolitan Venturi meter was accounted for. An attempt was made by the Department to locate possible leaks, but we were unable to find any of a serious nature. It was then decided to have a survey made, and a contract was entered into with the Pitometer Company of New York in the late fall of 1931. Work was started immediately and two buildings 6 ft. square were constructed to house the instruments, and a crew of four men and a small truck were supplied to work with the Pitometer engineer in charge.

To measure the flow of water in mains buried in the streets, an instrument known as the Pitometer is used. It includes two slender, metal tubes, so fashioned that they can be introduced into a main through a "tap" similar to that made for a house connection. The end of one tube points upstream; that of the other downstream. Greater pressure is thus created in one tube than in the other. By connecting the tubes with the ends of a U-tube of glass containing a colored measuring liquid, the pressures in the tubes are transmitted to the colored liquid, and the greater pressure depresses the liquid in one column of the U-tube. This difference in the columns is a measure of the velocity of the water, and the variations are recorded photographically on a chart. The velocity being known, the volume of flow can be computed.

*Superintendent of Water and Sewer Department, Lexington, Mass.

The scope of the survey made by the Pitometer Company consisted of dividing the town into five districts which were supplied with water through a single main and the flow into each area was measured with a Pitometer for 24 hours. To account for the minimum flow at night, when most water-using activities cease, is the problem. Therefore the survey proceeds to segregate first one block in an area and then to expand block by block, studying the increase in flow as each block is added. When a block shows an excessive rate of flow, an investigation is made with instruments which enable the investigator to hear the noise of water escaping from the leak.

### Total Consumption.

The total consumption was measured by a Pitometer on the 16-in. main over a 24-hour period. In order to have all the water supplied to the town pass through this main, it was by-passed through a 10-in. main. The results of the tests were as follows:

| | |
|---|---|
| Total Consumption | 695 000 g.p.d |
| Maximum Rate for One Hour | 1 000 000 g.p.d |
| Minimum Night Rate | 352 000 g.p.d. |
| Ratio-Minimum Night Rate to Total | 51 per cent. |

### District Measurements.

*District No. 1.* This district contains approximately 16 miles of main, and its character is middle and high class residential. It was isolated by closing several valves and the Pitometer measurement of the flow of water into this section was supplied through a 6-in. main. No leaks were found in this district.

*District No. 2.* This district is chiefly middle class residential and also includes part of the business section in the center of the town, consisting of approximately 20½ miles of water main. Two leaks were located in this district. One was a joint leak on an 8-in. main which was discharging 20 000 g.p.d. into an old drain; the other was a leak in a service that had been discontinued some 20 years ago. This service had been cut off on the house side of the curb, and it was found that the ¾-in. lead pipe leading from the main to the curb was split. The water from this leak was discharging into a catch basin nearby. The discharge from this leak amounted to 15 000 g.p.d.

*District No. 3.* This district is middle and high class residential consisting of approximately 10 miles of main. No leaks were found in this district.

*District No. 4.* This district is composed of middle class residences and the Middlesex County Hospital and includes approximately 8½ miles of water main. One leak was located in this district, a joint leak in a 4-in. main discharging 30 000 g.p.d. This leak was under a telephone conduit and was discharging into an underdrain which was used during the con-

struction of a trunk-line sewer and which was approximately 4 ft. deeper than the water main.

*District No. 5.* This district is middle and high class residential consisting of approximately 14 miles of main. Two leaks were located. One was a joint leak on a 4-in. main discharging 30 000 g.p.d. The water from this leak seeped through the ground a distance of approximately 1 000 ft. into a brook. The second leak was rather a difficult one to locate. It was found to be in a joint on a 10-in. main which had been cut off and capped. Two iron bars had been driven into the ground with several boulders of half-yard size to hold the cap in place. The cap had pulled away from the pipe about 2 in. causing a leakage of 50 000 g.p.d. The water in this case found its way through the ground for a distance of 10 or 20 ft. and was discharging into a surface-water drain.

## Test of Standpipe, Meters and Valves.

It was not possible to obtain a direct measurement of the leakage through the standpipe by means of the Pitometer. A measurement was obtained by shutting the standpipe off and noting the drop of water level by means of a pressure gauge. Several tests were made in this way over short periods of time but the drop in the water level was not sufficient to record accurately on the gauge. However, from these several tests the leakage appeared to vary from 3 000 to 5 000 g.p.d.

All meters 3 in. in diameter or larger were tested for accuracy in place under normal conditions. All were found to be registering correctly with the exception of one 4-in. meter supplying water to a large estate, which was found to be under-registering 20 per cent.

The valves of the distribution system were found to be in good condition. During the course of the survey two valves were found to be closed, but they placed no serious handicap on the system except by creating undesired dead ends.

## Summary.

During the course of the survey 5 underground leaks were located totaling 145 000 g.p.d. The industrial consumption amounted to 50 000 g.p.d. and this with the standpipe leakage made a total of 198 000 g.p.d. definitely accounted for by the survey. The balance represented the actual use by the people and the unavoidable leakage which exists in every water system. These were too small to justify the expense of locating and stopping them.

The Metropolitan Commission for the year in which this survey was made reported a total meter registration of 236 427 000 gallons, for which the Town was charged $22 688. Two-thirds of this charge, or $15 124 is for the actual quantity of water used, and is at the rate of $0.064 per thousand gallons. The leaks located which were wasting 54 000 000 gallons a year, at the above rate, cost the Town of Lexington $3 456 for the year.

| | Gallons | Per cent |
|---|---|---|
| Purchased from Metropolitan | 236 427 000 | 100 |
| Sold through meters | 126 760 000 | 53.5 |
| Underground leakage (145 000 g.p.d.) | 52 925 000 | 22.3 |
| Leakage in standpipe ( 3 000 g.p.d.) | 1 095 000 | 0.5 |
| Unaccounted for (slippage and stoppage in small meters, public uses, unavoidable small leaks in 69 miles of mains) | 55 925 000 | 23.7 |
| Total Use | 236 427 000 | 100 |

The total cost of this survey including the wages of men supplied by the town amounted to $2 831.55. The time required for the survey was 44 days.

## Discussion.

Patrick Gear.* Of what material were the joints that blew out?

Mr. Ross. They were all lead joints. This is my eleventh year in Lexington, and all extensions during my time have been made with compound joints. No leaks were found in compound joints.

David A. Heffernan.† At Milton, with 81 miles of pipe, for the year 1929 the unaccounted for water was 21.9 per cent.; for 1930, 19.9 per cent.; for 1931, 20.6 per cent.; for 1932, 19.7 per cent.; for 1933, 19.2 per cent.

Henry T. Gidley.‡ I would like to ask Mr. Ross if the master meter was tested.

Mr. Ross. It was. During the course of the survey the Venturi meter was tested and found to be registering correctly.

Mr. Gidley. The reason I asked is because I had a large amount of unaccounted-for water, and I found the meter was 15 per cent. fast.

*Superintendent, Holyoke, Mass. †Superintendent, Milton, Mass.
‡Fairhaven Water Co., Fairhaven, Mass.

# A RESUMÉ OF CHANGES IN PRACTICE AND RECENT IMPROVEMENTS IN WATER SUPPLY AT NEWTON, MASS.

BY RICHARD H. ELLIS.*

[*Read January 10, 1934.*]

A subject such as a resumé of a water department's activities over a period of some three and a half years, savors of annual reports which, while they might contain valuable and interesting data, would hardly be proper subjects for presentation before this ASSOCIATION. The recent work in Newton has however been somewhat unusual, and the author has attempted in the following presentation to cover the subject matter in a non-technical manner and to touch on various phases of management, design and practice so that there should be few who will not find something of interest.

*The City.* The city of Newton, having a population of approximately 70 000, is composed of ten almost independent communities including, Newton Corner, Newtonville, West Newton, Auburndale, Waban, Newton Highlands, Newton Upper Falls, Newton Lower Falls, Newton Centre and Chestnut Hill. Each of these communities has its own business center and one or more railroad stations, thirteen in all. It is interesting to note that there are ten different post offices located throughout the city.

The city as a whole contains some eighteen square miles of territory, the geographical center of which is but seven and nine-tenths miles from the State House in Boston. Located as it is, close to Boston, and being fortunate in having excellent train service, Newton has developed into a city populated largely by commuters. There are but few industries within the city, and the present zoning laws preclude the probability of much further industrial development—92 per cent. of the city being restricted to residential properties.

The growth of the city has been consistently rapid since 1880, the ten year increase varying from a low of 15.7 per cent. in the period 1910–1920 to a high of 41.8 per cent. during the halcyon period of 1920–1930. This rapid increase in population, with its accompanying demands, during the latter period has imposed upon the Newton Water Department, which in 1920 was already taxed to about the limit, some serious handicaps.

*Source of Supply.* Newton's water-works system was established in 1875. Ground water is obtained within a 677½ acre reservation situated south of the Charles River. The water obtained in this reservation flows at present by gravity through a 24-in. cast-iron pipe under the Charles River to a pump well located in the main pumping station on the Newton side of the Charles River.

*Water Commissioner, Newton, Mass.

In order to logically present the subject matter of this paper, the author desires to divide his discourse into two parts: (1) the result of a preliminary survey of the conditions which served as handicaps to proper and efficient management, a survey of the numerous complaints received, the reasons therefore and an outline of the corrective measures adopted; and (2) the development of a four-year program for the rehabilitation of the department.

*Preliminary Survey of Conditions.* The author's first impression upon becoming associated with the government of the city of Newton was that the shop routine and general office procedure were handicaps to efficient management. Subsequent investigation revealed that the primary reasons for this condition were as follows:

1. The working organization was without proper quarters.

A. There was no properly organized stock room nor was any attempt made to keep stock records.

(*a*) The only record of material used on a job was made up by the foreman and reported to the office for record and billing purposes on time reports.

(*b*) No check system was used to prevent the depletion of stock required.

B. Meter-repair work consisted merely of replacement of worn parts, and no systematic program for the inspection of meters was followed.

(*a*) Meters were removed and repaired only after they had been reported as stuck.

(*b*) Quarters were dark, crowded, and cluttered due to the fact that work of this nature was carried on in the same room with all other shop operations.

(*c*) No records were kept of meter repairs or tests.

2. The personnel was not properly trained to accomplish its work efficiently nor to properly render those services which the public has a right to expect from an efficient organization.

3. The office procedure (particularly as it applied to the issuance of rate bills) was inadequate for a community of approximately 70 000.

A. Severe peak loads were imposed on the general office and on the inspection force as a result of the practice of issuing simultaneously 15 500 water bills on January 1st and approximately 6 000 on July 1st, on an annual basis.

B. As a result of these peak loads, the public was disgruntled over the failure of the department to promptly report the result of the investigations of complaints, etc.

4. A serious situation existed which resulted in an almost infinite number of complaints of discolored and impalatable water.

5. The unit rate at which water was sold was unjustifiably high.

In order to undertake any work of a major nature it was evident that a properly laid out and well equipped shop was essential, and the government was first requested to grant authority to make studies which would lead to the development of such a structure.

*The Shop.* Studies were made to determine whether or not a new location would be more advantageous than that of the former shop, located

in Newtonville. Certain city-owned tracts in Newton Highlands would have brought the shop nearer to that territory which in all probability will see in the next twenty years the major development in Newton, but would have necessitated an average additional mileage of about two and a half miles and a consequent delay in responding to the more numerous emergency calls which normally would come from the more thickly and earlier developed sections of Newton, Newtonville, West Newton and

FIG. 1.—SHOP STRUCTURE BEFORE REMODELLING.

Auburndale. Preliminary sketches indicated that the development of a new structure of adequate proportions to provide for expansion would have cost in the neighborhood of $100 000.

The old shop had been built in 1892 as a combined shop and stable (Fig. 1). It was located at the intersection of two streets — Watertown and Edinboro. The latter was some eight feet higher in elevation than the former, thus providing two grade entrances, one to the shop and one to the stable. A third floor had, in the days of horse-drawn transportation, been used as a hay loft. From time to time a number of sheds had been built in the yard to house stock etc. and later to provide shelter for the automotive equipment.

The original studies indicated that it would be desirable to provide a total of 16 000 sq. ft. of floor space for the contemplated structure. In as much as there appeared to be as many disadvantages to any available new location as to that occupied by the existing shop, our attention was turned to the possibility of making some major alterations and additions

to it. A plan was developed which would make available 8 400 sq. ft. of floor space in the existing structure, and an addition of a block of 18 garage stalls, eight of which were assigned to dead storage, gave us an

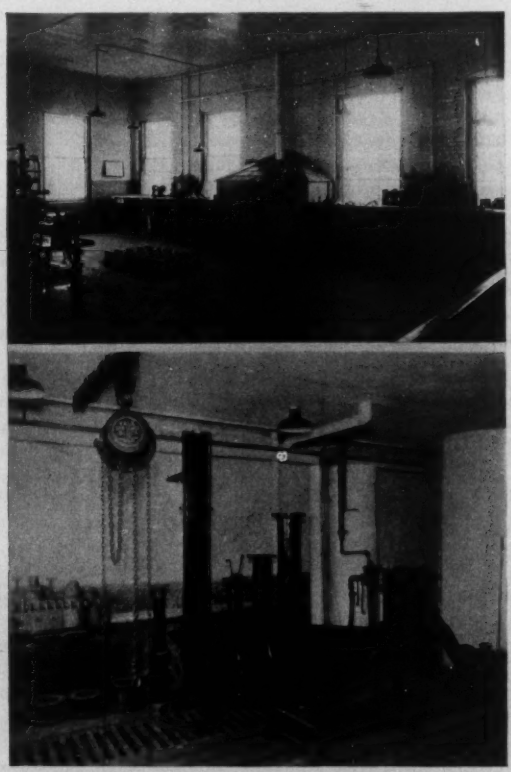


FIG. 2. ABOVE.—NEW METER REPAIR ROOM.
FIG. 3. BELOW.—NEW HYDRAULIC LABORATORY.

additional 4 700 sq. ft. making a total of 13 100. Due to the type of construction and the location selected for this latter structure considerably more room is available for additions to it as the growth of the department may require. The total cost of the remodelled building and the additions

represented an outlay of but $40 000—a net saving of $60 000 from the original plan for a new structure.

In the remodelled structure we were able to develop on the first floor:

1. Pipe shop, equipped with cutting and threading machinery (Fig. 2).
2. Laborer's room.
3. Locker room.
4. Hydraulic laboratory, used primarily for testing meters 2-in. or larger. This room is equipped with chain falls on track, etc. (Fig. 3).
5. Toilet facilities for laborers.
6. Disbursement room.
7. Boiler room.

The second floor was remodelled to accommodate:

1. Foreman's office.
2. Office and stock room to contain all small service stock, meter parts, etc.
3. Roomy meter repair and test room laid out to handle 4 000 to 8 000 meters per year and permit a five-year inspection program, three men being steadily employed.
4. Toilet room for meter-repair men and supervisors.

The installation of an elevator made the second floor easily accessible from either Watertown or Edinboro Streets and in addition permitted the development of the former hay loft into a storage room for tools and storage of unusual stock.

The garage as built is 90 ft. by 26 ft., provides accommodations for 10 vehicles and contains a wash stand and grease pit. All automobile maintenance is conducted at night by the night man on the first watch who in addition rings his watch clock every hour in the shop. Janitor service is rendered by the night man on the second watch. In this way all our cars are regularly serviced and the building is maintained in first class order without extra expense.

*Shop Records.* Upon completion of the shop it became possible to develop a logical shop practice. Proper stock records were installed providing a perpetual inventory so designed as to show the maximum and minimum amount of each item of stock it is permissible to carry, a coördinating requisition system whereby material required is requisitioned from the general office from which all material orders are issued. A job requisition system was installed whereby material required for work in progress is drawn from the stock room on a requisition bearing a job number. This number being the same as that appearing on the foreman's time record, the requisition sheet after having been entered by the stock clerk on his perpetual inventory is forwarded to the general office where it is filed until after the weekly payrolls are computed and checked. These payroll forms are so arranged as to set forth in addition to the aggregate time each employee works, the break-up of his work on any particular

part. The checking of the payrolls necessitates the calculation of the total value of all the work within the week on each and every job. The requisitions, each bearing the same job numbers as the payroll columns, are then readily combined with the labor tally and without being copied are transferred by the billing clerk directly to the bills and commitments or to the proper construction accounts.

*Meter Repairs.* The new meter shop provided by the remodelling of this plant was designed to accommodate the shop inspection of from 4 000 to 8 000 meters per year without further addition. This shop is equipped with a large drain tank into which all meters are placed on being brought into the shop. Here all exteriors are washed before the meters are removed to the repair bench which is equipped with upright drills, buffers, compressed air for drying and a sink with hot and cold water attachments for washing interiors. Acid tanks for thoroughly cleaning brass parts are conveniently located in a hooded and vented compartment accessible to all the repairmen. Testing apparatus and storage facilities are so placed as to reduce to a minimum the shop travel. A lathe is provided for necessary machinery of parts.

All stock used in the meter room is requisitioned from the stock room on meter job slips which are stamped at the beginning and end of the repair operation. The total repair cost—labor and parts—is calculated by the stock clerk, and a complete accounting of it is entered on a permanent meter-history card.

*Meter Records.* The meter records kept consist of an index by street and number of all services in the city, showing each meter set on each service, the date of setting, date of removal and the replacement. The meter-history card before referred to is indexed by make and number and shows where the meter has been set, dates of setting and removal, the reason therefore, the result of the test when removed, a notation of the condition of the meter, necessary repairs and their cost and the result of the final test. The city, by-owning all the meters, is enabled when removing meters for the purpose of inspection to replace them at the time of removal. A light truck mounted with a body designed especially for the service is used for this purpose.

Within the last two and three-quarter years, the department has removed, reconditioned and repaired 12 300 meters. The result of this work so far accomplished would seem to indicate that the net revenue gain will approximate 18 per cent., an amount equal to nearly 4.5 times the cost of the inspection work.

A rather unlooked for result of the furnishing of good working quarters was the increased moral of the working organization. The change of environment, the facilities available and the definite assignment of responsibilities together with the segregation of the several operations performed definitely increased the efficiency of the organization. The men were trained in the proper use and maintenance of the tools and equipment.

Definite efforts were made to offer advisory service based on actual surveys of conditions to those who reported a shortage of water in their house piping. Service records are being checked over and dead services disconnected at the main. A continuous hydrant inspection program has been operating for two years and a gate inspection program is to be started this spring.

*Former System of Reading and Billing.* The former system of reading and billing required that the meter reader or inspector should complete the reading of one complete ward before turning in his books. These ward books, of which there were seven, contained on the average 2 100 accounts each. The accounts, after being read were computed in the office, the computations entered in a ledger book from which the bills and commitments were copied. This procedure required the making of three copies, one by hand and two typewritten. All services were charged an annual minimum advance rate which was billed, together with any excess over the previous annual minimum as of January 1st. All meters were read semi-annually, and if water to the value of more than the minimum had been consumed by that time an "excess" bill was rendered as of July 1st. All "excess" water not so billed was charged on the subsequent annual bill rendered the first of the following year.

The system was confusing. It created two severe peak loads per year on the office organization, required the employment of temporary help and overwhelmed the inspection force following each billing period with such a volume of work that many of the inquiries resultant from the receipt of unusually high bills could not be promptly investigated. As a result the report lost much of its value due to the change in conditions which might meanwhile have occurred and the long period required to read all the meters before the billing date, and the public was unable to coördinate its use of water with the bills rendered.

Careful study of the possibilities of developing a more satisfactory system of reading, billing and inspection revealed the fact that the two regular readers, properly routed, and a supervising inspector who should investigate the complaints, pick up missed readings and untangle any irregularities reported, would be ample to handle the routine work involved in reading all the 15 500 meters quarterly.

*New Reading and Billing Procedure.* The city was divided into three districts and a stagger system developed whereby the meters in each of the three districts are now read four times a year at intervals of three months and in such a manner that no two districts are read within the same month. Modern billing machinery was purchased and a "bookless bookkeeping" type of billing procedure was adopted. All accounts are figured in the office and are entered in the original meter-readers' books, each of which contains on the average of 290 accounts or two days work. The billing operation is carried on simultaneously with the reading; the operator, after having prepared her bills and commitments on addressing equipment, fabricates at one operation both the bill and the commitment. Upon completion of the

billing operation the commitments, having been automatically footed to show the totals of the present and past readings, the consumption and the amount of the bills, are checked to eliminate the only possible chance for personal error—the calculation of the rate. Approximately 5 000 bills are thus rendered at the first of every month.

The whole billing process is a straightforward operation having no duplication of effort and requires no copying which would necessitate back-reading or a tedious checking operation and requires little more than one clerk's entire time.

The effect of the system as adopted was to entirely eliminate the peak loads on both the office and inspection forces, equalizing each month's work and thus enabling the department to render prompt service on the investigation of complaints which were greatly reduced due to the uniformity of the interval between readings. In general the public appreciated the receipt of a bill four times a year instead of at longer intervals, and the fact that full data as to the detail of the bill—including the date of reading, the present and past reading, the amount of the consumption recorded, all of which did not formerly appear,—was pleasing to the consumers. One other result that is of importance to the operation of the department is that the clerk, in calculating the consumption, reports daily to the meter department any meters which are failing to register. These meters are usually replaced by reconditioned meters within a period of three days.

*Quality of Water.* Throughout the entire year, but particularly during the summer months of greatest consumption, complaints in large numbers were received of discolored or unpalatable water. It was a known fact that the water as obtained at the source of supply is rather high in $CO_2$ and of a low pH value and therefore quite highly corrosive. Plans had been developed to conduct a rather large-scale experiment with several different treatment methods in order to determine which method was most suitable for use with Newton water.

*Experiment on Corrosion Control.* About the beginning of 1931, this experimental set-up was completed and put into operation, and by the end of the same year the department, basing its action on the experimental results, began a corrosion control treatment which we believe has been highly successful and has been largely responsible for the greatly improved condition of the water as drawn from the mains. Action on house piping has we believe been greatly minimized, and a direct saving thus should accrue to the house owner.

The details of this experiment and the treatment of the water being the subject matter of another paper to appear in this Journal, the author will trespass no further on the subject.

*Dead Ends.* An analysis of the many complaints received prior to 1930 indicated that the majority arose in districts which were fed by "dead ended" mains. Due to two primary reasons, the city of Newton had much more than its share of such mains. In all probability due to the demand

for main extensions during the ten-year period of maximum growth, 1920–1930, the distribution crews were unable to do much more than the minimum amount of work necessary to make water available to the new development which had sprung up. Thus few through connections were made during this period.

Another factor which the author believes contributed to the creation of the serious "dead ended" condition was the rigid pursuance of the practice of insisting on the guarantee of a proper financial return to the department for every dollar invested in main-pipe construction. Such a practice, while it has much merit, can be carried too far. Newton had proceeded along these lines to such an extreme that large portions of the distribution system suffered from lack of circulation and many large developments had inadequate fire protection. It was evident that for the good of the system it was inexpedient to follow this practice rigidly except in the case of new developments where the department insists on a satisfactory layout.

Appropriations were granted to start on a program of elimination of "dead ended mains." This work has been continually under way since the latter part of 1930. Great satisfaction has been expressed by residents of districts where this work has been carried to conclusion. As a result of the intensive work done during 1930 and 1931 in accomplishing or getting under way the work just outlined, the confusion which had previously precluded the possibility of logical and intensive study of some of the larger essential problems disappeared, and by the end of 1931 the department was able to develop a definite four-year program the completion of which has already yielded and is expected to further furnish very beneficial results.

*Four-Year Program.* During the latter part of the year 1931 a survey of the remaining most pertinent requirements of the department led to the formulation of a definite program the practical accomplishment of which is expected by the end of 1935. This program provided for the following improvements:

1. The elimination of "dead ended" conditions throughout the city by the construction of some 300 extensions having a total length of 18 miles at an estimated cost of $300 000. To date this project has served chiefly to take up any slack which might otherwise be encountered by the distribution crew. Of the work proposed about 25 per cent. has been completed to date.

2. The elimination of 6⅛ miles of 4-in. mains at an estimated cost of $100 000. No work under this project has been undertaken except in cases where highways have been resurfaced.

3. The reconstruction of 5 miles of distribution mains in Boylston Street in connection with the reconstruction of the Boston and Worcester turnpike, providing for the installation of a 16-in. trunk main on the north side of this highway and 6-in. and 8-in. distribution mains on the south side of the highway at an estimated cost of $92 000. This work has been completed within the estimated figure.

4. The development of the source of supply to enable the department to obtain the maximum amount of water available under the statutory limitations.

5. The remodelling of the pumping station and the installation of new pump equipment of greater capacity.

*Development of Source.* In connection with the fourth of these recommendations — the development of the source — the author desires to review briefly its development up to 1926 and then to describe the work done to make available the amount of water required.

Newton, as before mentioned, obtains its supply from 677½ acres of water-bearing gravel lands in Needham. Originally water was obtained by infiltration from the adjacent Charles River into a gravel basin through the center of which was constructed at a depth of 10 ft. below the surface a 4 ft. by 4 ft. wooden collecting conduit. From this conduit — 1 575 ft. in length, — the water was discharged by gravity through a 24-in. cast-iron pipe, under the Charles River to the pump well in the pumping station.

The yield from this infiltration basin proving inadequate within a short time and the depth of the filtering medium being insufficient, it was decided to continue the conduit 2 194 ft. — giving a total length of 3 769 ft. The conduit so constructed was fed by 209 2½-in. driven wells, the yield from which was so depleted by 1931 as to amount to a negligible quantity. The conduit also served to intercept the natural ground water flowing toward the Charles River.

As the demand for water increased, a dug well, known as Well No. 1, was constructed in 1911. This well, 28 ft. in diameter and 38 ft. deep is equipped with duplicate, vertical, motor-driven, submerged, centrifugal pumping units which discharge through a cast-iron main into the upper end of the wooden conduit.

Dug Well No. 2, installed in 1926 to further augment the supply, is 33 ft. in diameter and 42 ft. in depth and is equipped in a like manner to Well No. 1. This second well also discharges through a cast-iron main into the wooden conduit. The natural ground water supply to these wells is augmented as required by water from the Charles River pumped into three flooding or charging basins located in gravel hills west of the wells. The yield of the source so developed was 5 m.g.d. which was the maximum amount that the pumping equipment in the main station was capable of handling. Any peak requirements of water were of necessity purchased from the Metropolitan District Commission of Boston.

There were apparently three alternative courses open to the city: (1) to abandon its source and pumping plant and to purchase its entire supply of water from the Metropolitan District Commission; (2) to enter into an agreement with the Metropolitan District Commission whereby the city might as a matter of regular practice continue to purchase all water required beyond its ability to pump; (3) to develop the yield of its source and to install in its main station equipment of sufficient capacity as to make available the 8 m.g.d. of water to which the city is entitled under State regulations.

The terms as quoted by the Metropolitan District Commission for the

city's full requirements would have involved the expenditure annually for water of an amount equal to two and one-half times the 1930 cost of supplying its own requirements. This extra cost amounting to approximately $120 000 per annum diverted our studies to the other two courses available.

The amount of the saving which would have resulted from the retention of the city's own supply works under the second scheme was dependent only on the economies which could be developed in its operation. It was figured that the least amount of savings that would thus be returned to the city, provided modern equipment was installed to replace the then existing pumping equipment, would completely justify the expenditures necessary. This conclusion therefore led to further studies as to the feasibility of further developing the source and of installing pumping equipment of greater capacity and resulted in the adoption of the third available course.

Negotiations were opened which led to the purchase of 23 acres of gravel land, 300 ft. in width on which were developed two additional infiltration bowls or charging basins which together with the experimental bowl have given quite satisfactory evidence that the desired result has been obtained.

*The Pumping Station.* The main pumping station located on Needham Street in the Upper Falls was equipped with a 5-m.g.d. Worthington duplex compound unit installed in 1875 and a 5-m.g.d. Barr vertical cross compound pump installed in 1904. The boiler equipment consisted of two 150-lb. pressure 300, h.p. horizontal tubular Belpair boilers each of which was 42 years old.

In contemplating the installation of equipment of sufficient capacity to supply the needs of the city it was evident that there was little of value in the existing equipment. Studies were made of different types of machinery, including motor driven, Diesel engine and steam turbine equipment to determine that which was best adapted to Newton's requirements. Inasmuch as the use of several electrical units in the Water-Works Reservation required the operation of electric motors totalling about 125 h.p. the feasibility of installing generating equipment was considered on the two latter types—Diesel and steam turbine equipment. Since it had been found decidedly more economical to utilize the old structure than to build a new one the installation of Diesel equipment of acceptable design was more or less out of the question due to the space requirements and foundation difficulties.

Specifications were prepared and proposals and performance guarantees received on both motor-driven and steam-turbine-driven units with generators, and of 4-, 6- and 8-m.g.d. capacity. With the evidence thus secured as to the capital investment required and as to the operating costs under both schemes it was possible to evaluate the advantages of one type over the other. This procedure led to the selection of steam equipment and to the award of the contract for it, based on the cost and on the efficiency guarantees. Proposals were then received for the work involved in remodel-

ling the old structure, installation of two 250-lb. pressure, 250-h.p. water-tube boilers and auxiliary equipment.

Work was started on the remodelling of the station in September, 1932 and continued steadily until completion in August of this past year.

In connection with the accomplishment of this construction it is of interest to note that the city of Newton in generating the energy consumed in the Water-Works Reservation has reduced the cost of power from 9.9 to 4.15 mills per k.w.h., and the fuel cost for pumping water from $6.28 to the low of $3.75 per m.g. against a head of 274 ft., a net of $1.373 per m.g. per 100-ft. lift.

The total cost of developing the water requirements of the city at the source and of delivering the water into the mains has been reduced by at least $17 000, not taking into consideration the saving to be expected from our increased capacity. The amount thus saved compounded at 4 per cent. would depreciate the entire equipment within 10 years, the total cost of the installation being $199 350.

*Results.* As a tangible result of the whole work undertaken, the department, upon developing estimates for the work outlined in the four-year program previously referred to, and taking into consideration the increase in revenue which apparently was to accrue as a result of the meter-inspection work, was enabled to announce as of January 1, 1932 a rate reduction of 10 per cent. — from 25c to 22½c per hundred cubic feet. The economies subsequently effected, particularly as a result of the increased efficiency of the meters and the reduced pumping and power costs, permitted again on January 1, 1934 a further reduction of 11.1 per cent. from 22½c to 20c per 100 cubic feet as a base rate.

The entire work as outlined involving the expenditure to date of $468 000, with the exception of monies secured from the sale of $200 000 worth of bonds for extension purposes, has been accomplished from current revenue. The cash surplus in turn has been increased since 1929 from a deficit of $23 600 to a net surplus of $170 000.

In presenting this resumé of changes in practice and a review of the recent improvements in the Newton water system, recognition should be given to His Honor Mayor Weeks, and the members of the Aldermanic Boards of 1930, 1931, 1932 and 1933 who by their whole-hearted support have made these accomplishments possible.

# ENGINEERING PROBLEMS CONNECTED WITH RECENT IMPROVEMENTS TO THE NEWTON, MASS., WATER SUPPLYING WORKS.

BY GEORGE A. SAMPSON.*

[*Read January 10, 1934.*]

The purpose of this paper is to present some of the engineering problems connected with the recent extensive improvements to the water supplying works of the City of Newton, Mass.

Newton is a residential community adjoining the city of Boston. Owing to its geographical location, coupled with a well conceived civic development and many other advantages, the city of Newton, especially in the last two decades, has enjoyed a marked increase in population and water consumption, as recorded in Table 1.

TABLE 1.—POPULATION AND WATER CONSUMPTION.

| Year | Population | Water Consumption | |
|---|---|---|---|
| | | Gallons per day | Gallons per Capita per day |
| 1895 | 27 600 | 1 801 200 | 64.8 |
| 1900 | 33 587 | 2 086 400 | 62.1 |
| 1905 | 37 300 | 2 151 300 | 57.7 |
| 1910 | 39 806 | 2 505 400 | 62 5 |
| 1915 | 43 800 | 2 830 500 | 64.6 |
| 1920 | 46 054 | 3 699 400 | 79.6 |
| 1925 | 53 003 | 4 137 500 | 78.1 |
| 1930 | 65 276 | 5 002 700 | 76.6 |

## IMPROVEMENTS IN SOURCES OF SUPPLY.

*Existing Supply Sources.* The supply is a ground water obtained from an unusual gravel deposit along the Charles River in the town of Needham, the extent of the present sources being shown on Figure 1.

The original works were constructed in 1876 and were extended periodically to keep pace with the ever increasing water consumption. By the year 1920 a water consumption of 3 699 400 g.p.d. had again about equalled the capacity of the supplying works. At that time the collecting system consisted of the following parts:

(1). A 4 ft. by 4 ft. wooden infiltration conduit 3 769 ft. in length installed in 1876 and extended in 1889. Connected to this conduit are 209 2½-in. tubular wells driven into the gravel strata. If the yield from these wells was ever a substantial quantity of water, it is now negligible.

(2). A double 24-in. vitrified tile infiltration conduit 3 188 ft. in length, constructed in 1894 along the margin of a cat-tail swamp and discharging by gravity into a junction manhole at the upper end of the wooden conduit just south of Kendrick Street.

*Of Weston & Sampson, Consulting Engineers, Boston, Mass.

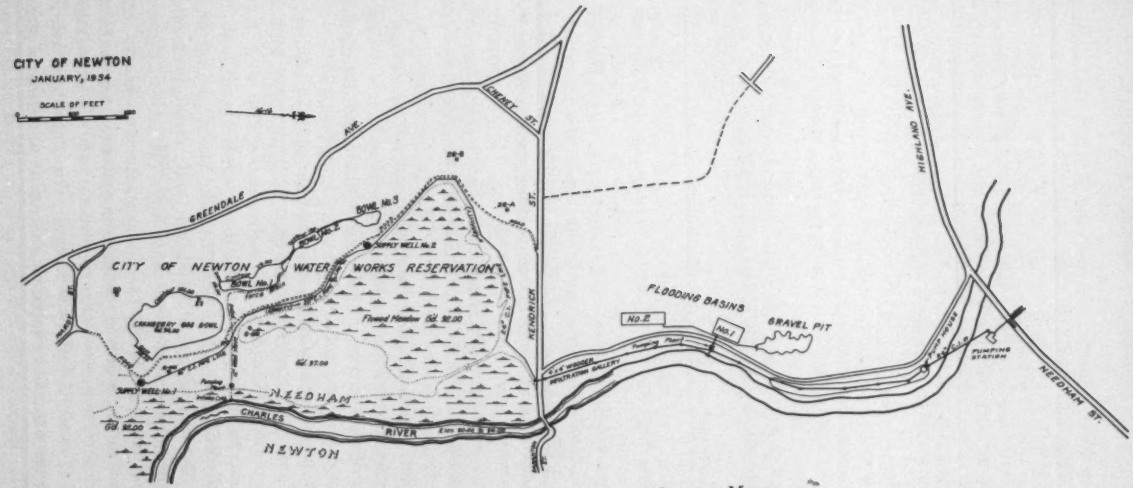



FIG. 1—SOURCES OF WATER SUPPLY, NEWTON, MASS.

(3). A 30-in. concrete collecting conduit 1 425 ft. in length, fed by a considerable number of 2½-in. driven wells. This conduit was laid in 1908 and 1909 and connected with the previously mentioned junction manhole.

(4). A large dug well (Well No. 1) of 28-ft. inside diameter, 38 ft. in depth, constructed in 1911 at a contract price of $8 990. This well is a concrete cylinder sunk into the gravel layer and is covered with a concrete dome roof. The well is located 3 595 ft. beyond the junction manhole and 500 ft. from the Charles River. Two vertical, motor driven, submerged centrifugal pumping units, each with a capacity of 1.5 m.g.d., discharging through a 24-in. vitrified tile pipe, 2 170 ft. in length, into the upper end of the 30-in. concrete conduit.

(5). A 24-in. cast-iron gravity supply main, 750 ft. in length, extending beneath the Charles River and connecting the lower end of the wooden conduit with a pump well at the main pumping station in Newton Upper Falls.

The average yield of these ground water sources for the period from 1920 to 1925 inclusive was 3 775 000 g.p.d. as follows:

| | Gal. per day |
|---|---|
| Wooden conduit | 2 000 000 |
| Double 24-in. tile conduit | 750 000 |
| 30-in. Concrete conduit | 225 000 |
| Dug Well No. 1 | 800 000 |
| Total Yield | 3 775 000 |

*Changes in and Additions to Supply.* In 1921, the city, for the first time, purchased 5 m.g. of water from the Metropolitan Water Works and in 1925 the water purchased reached 176 m.g. The water supply problem was then studied by a special committee of the Board of Aldermen of the city of Newton, assisted by Mr. J. C. Whitney, a former Secretary and President of the New England Water Works Association, then Water Commissioner; by the Engineering Department of the city of Newton; by the Massachusetts Department of Public Health, and by the writer's firm as consulting engineers. It was decided to augment the ground water sources at once by constructing another large dug well (Well No. 2) at a location that was selected after driving a number of 2½-in. test wells.

*Well No. 2.* Well No. 2 was completed in the spring of 1927 and the pumping equipment installed in the early summer. The well is 33 ft. in inside diameter by 42 ft. in depth, sunk into the gravel at the foot of a large upland water-bearing area and just above the cat-tail swamp previously mentioned. The well casing is of 16-in. reinforced concrete, perforated with 60 4-in. diameter holes in three rows in the lower 12 ft. After the excavation had progressed to a depth of 8 ft. and into ground water a concrete cylindrical ring with a cutting edge was cast in place and sunk by excavating from within. Successive rings were then constructed and the excavation progressed until the desired depth was attained. The contractor was equipped for removing the material by pumping, but owing to the size of the stones encountered in the gravel this method had to be abandoned. A clam shell

bucket was then used and the excavation substantially unwatered during the progress of the work. Although some difficulty was experienced in sinking the cylinder vertically, this was overcome by digging on the high side and bracing against the outside of the shell. Real trouble was encountered, however, when the outside gravel began to slide under the bottom of the casing which developed into cave-ins 20 ft. wide at the top. As a result, the excavation removed was at least twice the contents of the cylinder and a large amount of backfill was required.

The contract price for constructing the well, including a concrete roof and small brick pump house, was $11 400. This figure does not represent the actual cost to the contractor, nor is it more than one-half of a fair average price for a well of this type and size.

The pumping equipment consists of two, duplicate, vertical, motor driven, submerged, centrifugal pumps, each designed for a capacity of 2 772 000 g.p.d. The contract price installed, including the electrical work, was $4 646.

The natural yield of Well No. 2 was found to be 1 160 000 g.p.d.

*Sources Abandoned.* The results of a sanitary survey in 1926 showed that the double 24-in. tile infiltration conduit and the 30-in. concrete collecting conduit were so located as to be affected by high water in the Charles River and that at such times these sources furnished a supply of inferior quality. It was, therefore, thought advisable to abandon these two conduits which furnished 975 000 g.p.d. When this decision was reached it introduced the problem of conveying the discharge from Well No. 1 and from the proposed Well No. 2 to the wooden conduit. It was decided to install a cast-iron main skirting the swamp, consisting of 1 310 ft. of 16-in. and 1 315 ft. of 20-in. pipe from Well No. 1 to Well No. 2 and 3 185 ft. of 24-in. pipe from Well No. 2 to the wooden conduit. The 16-in. size was used to provide for a possible future dug well south of Well No. 1 and the increase to 20 in. was decided upon to serve another possible well midway between Wells No. 1 and No. 2.

The completion of Well No. 2 and the abandonment of the tile and concrete conduits resulted in a net increase in yield of only 185 000 g.p.d., to a total of 3 960 000 g.p.d. as compared with an average daily water consumption for the year 1927 of 4 420 000 gal.

*Flooding Basins.* The next step in the development was an experiment to determine the practicability of increasing the yield of Wells No. 1 and No. 2 by pumping water from the Charles River into a natural basin in the gravel hills situated between and above the two wells in the location of Bowl No. 1, as shown in Figure 1. This experiment is of especial interest as it marked the beginning of a flooding development to augment the ground water supply which is rather unusual in this country.

An area in the form of a cross with a width of 40 ft. and a total length of 700 ft. was cleared of scrub oaks and stripped to the gravel. In the meantime a temporary electric motor driven centrifugal pump with a capacity

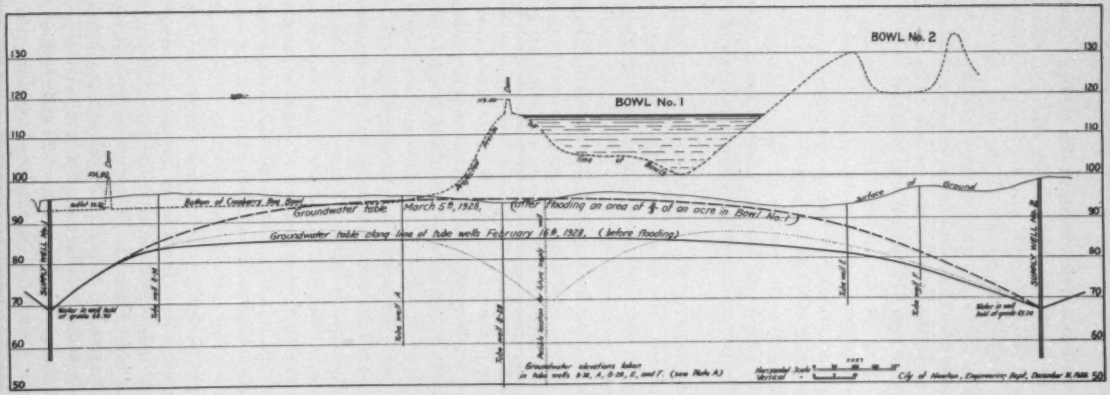

BOWL No. 2
BOWL No. 1
Groundwater table March 5th, 1928, (after flooding an area of ¾ of an acre in Bowl No. 1)
Groundwater table along line of tube wells February 16th, 1928, (before flooding)
Surface of Ground
Bottom of Concrete Pipe Sewer
Groundwater elevations taken in tube wells B-W, A, B-28, E, and F. (see Note A)
City of Houston, Engineering Dept., December 31, 1928.

FIG. 2—EFFECT OF FLOODING BOWL NO. 1 ON GROUND WATER TABLE.

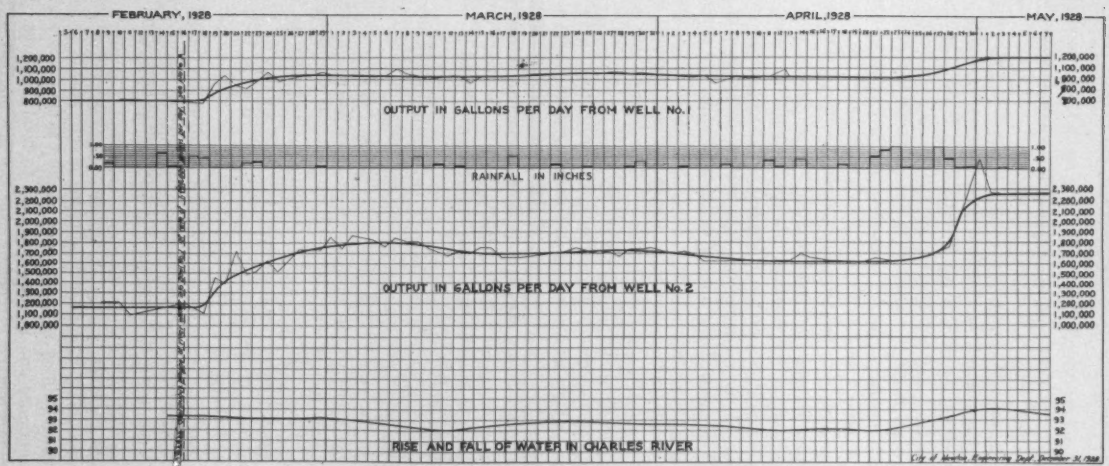

FEBRUARY, 1928
MARCH, 1928
APRIL, 1928
MAY, 1928
OUTPUT IN GALLONS PER DAY FROM WELL No. 1
RAINFALL IN INCHES
OUTPUT IN GALLONS PER DAY FROM WELL No. 2
RISE AND FALL OF WATER IN CHARLES RIVER

FIG. 3—EFFECT OF FLOODING BOWL NO. 1 ON YIELD OF WELLS.

of 1 400 000 g.p.d. was erected near the river and a 12-in. wood pipe force main laid from the pump to the basin. Continuous flooding began on February 16, 1928. After two days of pumping a rise of several inches was noted in the elevation of the water in several 2½-in. test wells driven along the margin of the swamp. At the same time there was a slight increase in the yield of Well No. 1 and Well No. 2, particularly No. 2. On March 5 the yield of Well No. 1 had increased from 800 000 to 1 030 000 g.p.d. and Well No. 2 from 1 160 000 to 1 800 000 g.p.d. or a total increase of 870 000 g.p.d., and the ground water between the wells had risen several feet as indicated in Figures 2 and 3. From a flooding area of 0.64 acre, 870 000 g.p.d. or 62 per cent. of the water pumped from the river had been collected in the wells about one-quarter mile distant.

Before and during the flooding, numerous samples of water were collected from various 2½-in. test wells located at different distances from the basin, and from Wells No. 1 and No. 2, in order to determine the radius of influence of flooding on the quality of the ground water. In general it was found that a lateral distance of 150 ft. from the flooding basin to the point of collection was more than ample, in the rather coarse gravel strata, for the complete purification of the river water. This distance was established as a minimum in the design of subsequent flooding basins.

Following this successful experiment the entire area of Bowl No. 1 amounting to 1.8 acres as well as another nearby natural basin at a higher elevation—Bowl No. 2 with an area of 0.65 acre—were stripped to the surface of the gravel during the fall of 1928. A permanent intake crib and a pumping station equipped with a 3 500 000-g.p.d. electric motor driven centrifugal pump were constructed at the river and the 12-in. wood pipe line was extended to Bowl No. 2.

The new flooding system was placed in operation early in 1929 and has been used since that time for augmenting the yields of Wells No. 1 and No. 2. Later in the year 1929 a third basin (Bowl No. 3) located directly above Well No. 2 and 150 ft. distant was constructed to serve as a more direct supplement to this well. With the three bowls the yields of Wells No. 1 and No. 2 were 1 030 000 and 2 300 000 g.p.d. respectively, or a total of 3 330 000 g.p.d. which is an increase of 1 370 000 g.p.d. over the natural yield. The amount of water pumped from the river is controlled by throttling the discharge valve at the pump and is varied in accordance with the need for flooding. To recover 1 370 000 g.p.d. requires about 2 500 000 g.p.d. of flooding water. The total yield of the ground water sources was now 5 330 000 g.p.d. but still inadequate for periods of only slightly greater than average consumption.

*Additional Flooding.* The next step in developing the ground water supply was another experiment in flooding in the early part of 1930. A gravel pit located about midway of the wooden conduit as shown in Figure 1 had just been abandoned and it seemed logical to flood this area. The main advantage in this method of flooding over the first method is found in a

single pumping. The water is collected directly in the wooden conduit instead of in wells and one pumping is eliminated.

After a temporary pumping station had been erected at the river and a force main installed, flooding began in May 1930. Within two days there was an increase in the water level in the wooden conduit of 3 in. About 1 000 000 g.p.d. were then discharged continuously into the gravel pit for several weeks, of which 750 000 g.p.d. were intercepted by the wooden conduit. The minimum lateral distance from the pit to the conduit was 150 ft., and here again the sanitary protection was ample. The results of this flooding were even more satisfactory than for Wells No. 1 and No. 2.

The total yield was now 6 080 000 g.p.d., and it seemed quite certain that the sources could be developed to the full allowable legal limit of 8 000 000 g.p.d. by constructing two or more artificial flooding basins on the gravel area above the wooden conduit between the experimental gravel pit and Kendrick St. The legislative regulations under which the city of Newton obtains water from the Charles River and the adjoining water works reservation as finally enacted in 1913 and approved by the Massachusetts Department of Public Health are as follows:

8 000 000 g.p.d. at all times between December 5 and June 5.
8 000 000 g.p.d. from the 5th of any month to the 5th of the following month from June 5 to December 5 when the rainfall for the preceding six calendar months as determined by averaging the rainfalls at several nearby prescribed gaging stations exceeds 19 in.
7 000 000 g.p.d. when the rainfall is less than 19 in. but exceeds 18 in.
6 000 000 g.p.d. when the rainfall is less than 18 in. but exceeds 17 in.
5 000 000 g.p.d. when the rainfall is less than 17 in.

After these developments the amount of water that could be supplied to the city was limited not so much by the source as by the pumping equipment at the main station across the river. The main operating unit was a Barr, vertical, crank and fly-wheel, cross-compound steam pumping engine installed in 1904, limited to a maximum capacity of 5 200 000 g.p.d. but more judiciously operated at 4 500 000 g.p.d. A standby unit consisted of a 5-m.g.d. Worthington, horizontal, compound, duplex, double acting, steam pumping engine installed in 1875 and operated only as necessary. The real problem had now shifted from the source of supply to the pumping station.

At this stage Richard H. Ellis, President of the New England Water Works Association during the past year, was appointed Water Commissioner and with the assistance of the writer's firm as consulting engineers, began an intensive study of the pumping facilities. Following a decision to provide a pumping capacity of at least 8 000 000 g.p.d. the next and last step in the development of the sources to meet this demand was begun.

After considering additional dug wells it was decided to further flood the area above the wooden conduit. Two flooding basins were constructed as shown in Figure 1, having a total area of 1.7 acres and a permanent pump-

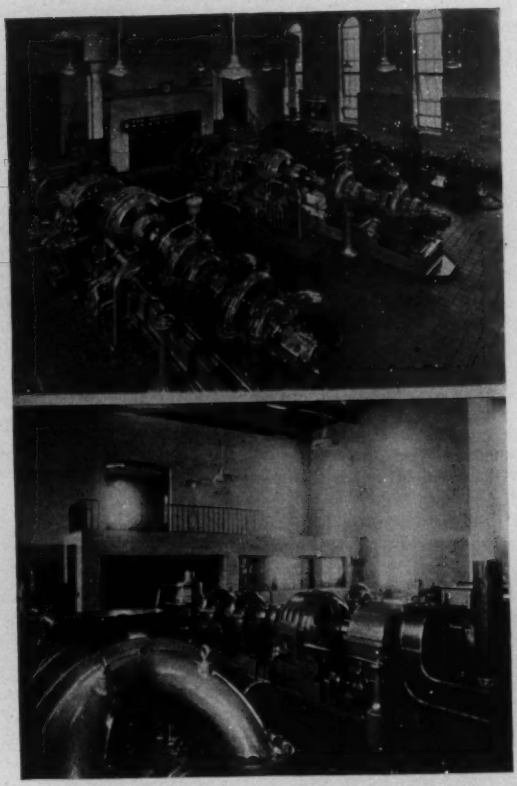


FIG. 4.—MAIN FLOOR OF REMODELLED PUMPING STATION

ing station for delivering water to the two basins and to the gravel pit. This flooding plant was placed in operation in the early summer of 1933 and has been in operation since that time as necessary to maintain a suitable ground water elevation in the wooden conduit. Although the yield of the sources as now developed has not been tested for a sufficient period it is believed that at least 8 000 000 g.p.d. are available, more than 50 per cent. of which are the result of flooding gravel areas.

## Improvements in Pumping.

*Pumping Station.* The decision to install new pumping equipment of increased capacity was reached only after an extended comparison between developing the Newton supplying works and changing to the Metropolitan supply, in whole or in part. It was found that the city was not justified in shouldering the additional cost for Metropolitan water.

Early in 1932 preliminary comparisons of various types of pumping machinery were begun, including electric motors, steam turbines and Diesel oil engines as prime movers. On account of the increased first cost, additional space required, foundation difficulties and other related reasons connected with Diesel engines, the comparison was finally confined to electric motor and steam turbine driven centrifugal pumps, the latter units without and with attached generators for developing electric power for the motor driven pumps in the water works reservation, electric lighting, etc.

Although preliminary proposals for both electric and steam units seemed to favor steam power, it was decided to prepare specifications and to receive formal bids on both types of pumping equipment. Because the then existing steam plant consisted of two 300-h.p. Belpaire locomotive type boilers installed in 1890 with a maximum allowable steam pressure of 125 lb. and no superheat, bids were also invited on a new boiler plant.

Proposals were received on June 15, 1932 and after an exhaustive comparison of installation costs, fixed charges, operating costs and other factors the decision was reached to install steam turbine driven centrifugal pumps with generators and to replace the boiler plant, using pulverized coal for fuel.

Following this decision the contract for the pumping equipment was awarded to the Turbine Equipment Company of New England and for the boilers to the Erie City Iron works.

*Pumping Equipment.* There are three pumping units each consisting of a steam turbine, double helical reduction gears, alternating current generator, exciter and two pumps in series, as shown in Fig. 4. The generators and exciters were furnished by the Electric Machinery Mfg. Company. The De Laval Steam Turbine Company made the turbines, gears, pumps and cast iron bed plates and mounted the units.

The three generators are duplicates, each 200 k.w. at 80 per cent. power factor, 3 phase, 60 cycle, 4 000 volt, alternating current. The exciters are

mounted on the main shaft. The guaranteed efficiencies of the generators vary from 94.4 per cent. at full load to 92.0 per cent. at one-half load.

The principal characteristics of the units are given in Table 2.

TABLE 2—PUMPING UNITS.

| Item | Unit No. 1 | Unit No. 2 | Unit No. 3 |
|---|---|---|---|
| Number of Stages of Turbine | 9 | 9 | 9 |
| Speed of Turbine—r.p.m. | 5 980 | 6 060 | 6 069 |
| Speed of Generator and Pump—r.p.m. | 1 200 | 1 200 | 1 200 |
| Brake Horse Power of Turbine. | 600 | 775 | 1 000 |
| Capacity of Pump—g.p.m. | 2 950 | 4 175 | 5 560 |
| Dynamic Pumping Head—ft. | 272 | 295 | 340 |
| Capacity of Generator, k.v.a. | 250 | 250 | 250 |
| Guaranteed Efficiency of Pumps—per cent. | 85 | 86 | 87 |
| Steam Pressure at Turbine Throttle—lb. per sq. in. | 230 | 230 | 230 |
| Superheat at Turbine Throttle—°F. | 125 | 125 | 125 |
| Vacuum at Turbine Exhaust—in. Mercury | 29 | 29 | 29 |
| Guaranteed Duty—ft. lb. per 1000 lb. steam at 115 k.w. generator load. | 168 200 000 | 186 600 000 | 183 400 000 |
| Guaranteed Water Rate—lb. per b.h.p. hr. at 115 k.w. generator load | 10.6 | 9.7 | 10.0 |

*Pump Well.* The water from the sources flows by gravity to a pump well beneath the floor of the pump room which is at elevation 95.75. The capacity of the well is 20 000 gal. with the bottom at about elevation 82.25. The supply enters through a 24-in. butterfly valve equipped with a float to close the valve when the water reaches elevation 93.5. The water passes through a set of fine bronze wire screens (4 meshes per lineal inch), raised by a ½-ton electric hoist, and then into the suction well. The level of the water in the well is shown by an indicating float gage with a red hand set at the low-water danger point. In the screen chamber the water is treated with soda ash by means of a dry chemical feeder to neutralize its corrosive action and with liquid chlorine as a disinfecting agent.

Each pump has a separate suction ending in a bell-mouth at elevation 83.25. A water works type surface condenser is installed in each suction main beneath the pump room floor. Forced injection water from the city supply is also provided for each condenser until the pump is in operation or in case it is desired to run the generator without the pump. Each condenser is equipped with a 6-in. atmospheric relief valve discharging into the suction well.

*Pumps.* The pumps have a bottom suction and horizontal discharge with the series piping extending beneath the floor. The discharge from the second-stage pump is through the floor and through a horizontal swing check valve and hydraulically operated gate valve to a 24-in. force main outside of the pumping station connecting with the distribution system and a 10-m.g. covered concrete storage reservoir on Waban Hill having a flow line at elevation 320. The hydraulic cylinders of the valves are operated by

a lever handle 4-way cock mounted on a floor stand near the turbines. A 24-in. Venturi meter tube is installed in the 24-in. force main with an indicating, recording, registering instrument erected on the floor of the pump room near the switchboard.

The pumps are primed by a steam jet air pump, the main function of which is to remove the air from the condenser. The casings of the pumps are connected through an air valve to the first stage where a vacuum of 25 in. of mercury is maintained.

By substituting new impellers only, of slightly larger diameter, the pumps will deliver 5, 7 and 9 m.g.d., respectively, against the corresponding pumping heads. The steam supply, turbines, gears, shafts and other details are designed for the increased horse powers even with the generators developing full load.

*Condensate.* An interesting feature of the installation is the method used for removing the condensate from the condensers by means of Schutte & Koerting water eductors submerged in the suction well. Each eductor is supplied by a 2-in. pressure line from the city main, the water first passing through the turbine oil cooler and steam jet air pump. The water used through the eductors returns to the suction well and amounts to 25, 33 and 40 g.p.m. for the three units, or about 0.75 per cent. of the discharge of the pumps.

*Oiling System.* An oil reservoir is provided in the base of each turbine. The oil pump connected with the turbine takes oil from this reservoir and delivers it through an oil cooler to one of three overhead storage tanks of 150-gal. capacity located on an elevated platform in the boiler room. From the overhead tank in use, the oil flows by gravity through a centrifugal purifier and is then delivered by a 1/6 h.p. motor driven rotary pump to the turbine gears and bearings through a sight glass and strainer. The excess oil pumped to the overhead tank and not used through the purifier is returned to the reservoir through an overflow pipe.

Each turbine is also equipped with an auxiliary oil pump for use in circulating the oil before the turbine pumps are in operation. No. 1 turbine is provided with a steam driven reciprocating oil pump located beneath the pump room floor. Turbines No. 2 and No. 3 are equipped with rotary oil pumps driven by a 1-h.p. motor and mounted on a steel bracket near the reduction gears. No. 1 unit can then be started even if electricity is not available.

Thermometers are mounted at the inlet and outlet ends of the oil cooler and on the oil feed line to the gears and bearings. A sight flow indicator is also inserted in the outlet line from the oil cooler.

*Switchboard.* The electrical switchboard was furnished by the Electric Machinery Mfg. Company and is of the "dead front" type with the bus and switch structures, transformers and other equipment located in a brick vault behind the board, access to which is through a door at one end.

In addition to the usual electric meters, switches, controls and syn-

chroscope the switchboard is also provided with a push button station for controlling the four pumping plants in the water-works reservation. There is a "start" and "stop" button for each plant and indicating lights as follows: When the "start" button is pushed the completion of the electric circuit is indicated on the switchboard by an amber light. As soon as the pump is delivering water this fact is shown by a green light which is actuated by a pressure switch connected to the discharge main near the pump. The distance from the switchboard to the auxiliary pumping stations varies from ½ to 2 miles.

*Gage Board.* The gage board and gages were furnished by the Ashton Valve Company. The gages are of the flush front type, 10-in. in diameter and with chromium-plated brass cases. They consist of a recording water-pressure gage connected with the discharge pipe from No. 1 pump beyond the gate valve; an indicating water-pressure gage connected by a header to the discharge nozzles of the three units; an indicating steam-pressure gage connected with the steam header in the pump room; an indicating steam bleeder pressure gage connected with the header beneath the pump room floor; an indicating water vacuum gage connected by a header with the suction nozzles of the first-stage pump of the three units; an indicating steam vacuum gage connected by a header with the exhaust flange of each turbine; and an indicating mercury absolute pressure gage connected to the turbine exhaust header leading to the vacuum gage.

*Regenerative Cycle.* In order to obtain more useful work from the steam than would be secured in its normal passage through the turbine and condenser a 2-in. extraction steam line was tapped into the third stage of the turbines and carried to the open de-aërating, boiler feed water heater in the boiler room. The utilization of the heat in this steam after it had performed its major work in the turbines resulted in an economy approaching 5 per cent., depending on the amount of steam extracted, which in turn was governed largely by the pumping and generating load on the turbine.

*Pumping Station Building.* The pumping station and boiler room were built in 1876 at the very beginning of the water works. The buildings are of brick with slate roofs supported on wooden trusses. In 1904, after 28 years, the entire roof of the pumping station was raised 12 ft. to accommodate the vertical Barr steam pumping engine installed at that time. Last year, after a further lapse of 29 years, the roof was lowered the same 12 ft. because the added height was undesirable for steam turbine units.

The alterations in the pumping station, boiler room and coal pocket, both inside and outside, were made under the supervision of Clifford S. J. White, Architect, and by Richard White Sons, Inc., Contractor, both of Newton. Extensive changes were made in the interior both as to structural design and architectural finish. The pump room is well adapted to its function and presents an attractive appearance. The floor is concrete covered with red tile laid in cement mortar. The lower portion of the walls is of light buff, glazed tile blocks and the upper portion of acoustic plaster.

*Duty Tests.* Witness tests were made of each pump at the De Laval shops before shipment in order to be assured that the guaranteed duties were likely to be obtained. After all three units were completely installed and had been in regular operation for several weeks, final acceptance tests were made on November 21, 23 and 25, 1933, with very satisfactory results. The duties in ft.-lb. per 1 000 lb. of steam with generator loads of about 115 k.w. were as follows:

| | Foot pounds |
|---|---|
| Unit No. 1 | 188 013 000 |
| Unit No. 2 | 194 060 000 |
| Unit No. 3 | 191 220 000 |
| Average of three units | 191 100 000 |
| Guaranteed average duty | 179 400 000 |

Average test duty exceeds guarantee by 6.5 per cent.

*Pumping and Generating Costs.* Although records of normal operation are available only for a short period the cost of coal for pumping and generating is about as follows. The price of coal suitable for use with the pulverizers is now $4.18 per net ton. Cost of coal for pumping water equals $3.75 per m.g. against a dynamic head of 274 ft. or $1.37 per m.g. per 100 ft. Cost of coal for generating electric power is 0.415 cents per k.w.hr. at the switchboard.

The former Barr pump had a station duty of 114 000 000 ft.-lb. per 1 000 lb. of steam and the cost of pumping at the same price for coal would be $6.28 per m.g. The saving in coal with the new pumping equipment, based on the present water consumption of 5 m.g.d., amounts to $4 600 per year. At the same time the cost of coal for generating power and light is $4 200 per year as against a former cost for purchased electricity, after an allowance for operating a new flooding pump, of $17 200 per year. The saving in electricity is $13 000 per year and the total saving $17 600 per year. This economy will increase with the water consumption.

*Construction Cost.* The cost of the complete remodelling of the pumping station, pumping equipment, boiler plant, coal pocket, outside piping connections and appurtenances including architect's fee, engineering and miscellaneous expenses was about $200 000.

# BOILER PLANT
# NEEDHAM STREET PUMPING STATION.

BY DAVID EAMES.*

[*Read January 10, 1934.*]

The boiler plant of the Newton pumping station was completely modernized with new equipment without interrupting operation and without making any change in the building except to lower the floor level by about one foot.

The roof of the building is supported on two timber trusses dividing the width of the building into three equal bays. The headroom under the trusses of 18½ ft. was not sufficient for the boilers, so the arrangement adopted was to locate one boiler in each outside bay and the auxiliary equipment in the central bay.

The boilers are supported on steel columns independent of the building. These columns were designed heavy enough to carry also the overhead coal bunkers and the elevated feed-water heater platform as well as the access galleries at the sides and top of the boiler. The entire floor space was thus left clear for equipment.

The original square brick chimney, 105 ft. high, was not changed and is being used with complete success for the new boilers. The limited draft from this low chimney required careful consideration, however, in working out the design.

The capacity of the boiler equipment was determined by reference to the steam demand of the turbine when driving the largest of the three pumps and with full electrical load on the generator. Each of the two new boilers has capacity for this load so that only one boiler is in operation at any time, the second being in reserve. The full steam demand on the boiler including the main turbine and all auxiliaries is between 9 000 and 10 000 lb. per hour.

The boilers are watertube, of the cross drum straight tube type with 2 500 sq. ft. of heating surface, and are set 10½ ft. high from the floor to the bottom of the front header. The boilers have superheaters designed to give about 150° F. superheat to the steam. The operating steam pressure is 240 lb. per sq. in. and the total temperature of the steam is 550° F. which is 200° F. higher than the steam temperature of the original plant.

No attempt was made to secure high overload capacity from the boilers. For one reason, the available draft from the chimney is insufficient for high ratings, and for another reason, the small boilers and furnaces such as we have here, are best suited to conservative operating rates. When supplying the maximum steam demand of 10 000 lb. per hour the boiler will be operating at 135 per cent. of rated capacity.

*Consulting Mechanical Engineer, Boston, Mass.

The boiler feed-water is drawn direct from the river through the intake which was used for the same purpose by the original plant. The water is handled by small motor-driven pumps, in duplicate, and after leaving the pumps, passes through the steam-jet air-pump condensers at the main turbines where it reclaims several degrees of heat which would otherwise be lost. The water next passes through a closed-type feed-water heater which uses exhaust steam from the boiler feed pumps. The feed water then goes to the open de-aërating heater and thence by gravity to the boiler feed pumps. The open heater is supplied with steam extracted from the main turbines which has consequently done a certain amount of useful

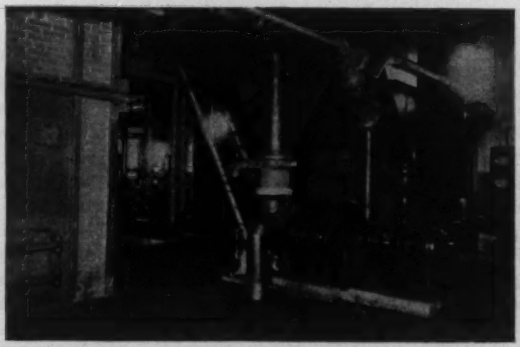


FIG. 1.—BOILER ROOM OF PUMPING STATION.

work before entering the feed-water heater. The pressure of the extraction line varies from atmospheric up to 5 or 6 lb. per sq. in. depending on which pump is running and what the load is. The feed-water temperature entering the boiler ranges from 212 to 225° F.

The steam leads from the boilers to the turbine room are 4 in. in size, and the throttle connection for each machine is 3 in. in size. The two 4 in. leads form a loop through the turbine room, with all stop valves conveniently accessible from the top of switchboard enclosure.

To go back to the fuel supply for the station, I think we would have decided to use oil had it been available at a price comparable with coal. As this was not the case, coal was chosen. The station has a large covered coal pocket dug into the side of the hill so that the coal is unloaded from an overhead gallery. This is the same arrangement as has always been in effect except that a platform scale has been installed on the gallery for weighing all coal as received.

The mechanical coal-handling system starts with a hopper at the boiler-room side of the coal pocket. Coal is wheeled to this point. After

passing through a grizzly to exclude lumps, it is then raised to upper part of the coal pocket by a bucket elevator which discharges to a screw conveyor. This in turn passes horizontally into the upper part of boiler room where it discharges into a small hopper located above the scale in which the coal is automatically weighed and from which it is discharged into the bunkers below. To prevent over-filling, the hopper over the scale is fitted with an automatic arrangement so that when it is nearly full the starter on the driving motor is tripped out and the entire conveying system shut down. This automatic feature is made use of three times a day by the different shift firemen in their regular filling of the bunkers.

Coal, after leaving the scale, is diverted by a flap damper into either of the two bunkers, one for each boiler. The shape of these bunkers was determined after careful study so that there would be a minimum of trouble due to arching of coal. The fuel has great tendency to do this, especially when wet. The bunkers, as built, have two adjacent sides vertical from top to bottom. The other two sides slope at 60 deg. from the horizontal. The corner between the vertical sides is rounded to a radius of 6 in., exactly conforming to the shape of the gate at the bottom. The results with these bunkers have fully met the expectations of their design.

A controlling feature in the design of the boiler room was to produce something which would be in keeping with the high-grade pumping equipment which was under consideration. This purpose found its fullest expression in the selection of pulverized coal as the method of firing. This is the cleanest, most efficient, and most up-to-date method of burning coal, giving boiler efficiencies of 78 to 80 per cent. against 71 to 72 per cent. for a stoker of type suitable for this plant. This represents at Newton a yearly fuel saving of $1 400 whereas the extra cost of the pulverizing equipment was $700, both values being stated in round numbers. The operation at Newton shows continually the three points which indicate high boiler efficiency, *viz.* high $CO_2$, low exit-gas temperature and a clean stack. A very important feature of a pulverized-coal installation is the design of the furnace. At Newton the furnaces are of the solid-wall type, without air or water cooling, and are amply large for the expected capacities. After about 6 months of service they show no spalling or other signs of failure. The new equipment is being operated by exactly the same men who formerly shovelled coal in the old plant, and there has been comparatively little to criticise in the way they have taken hold of the new ideas. I feel safe in saying that on the whole, the pulverized-coal system is proving eminently satisfactory, in the Needham Street Pumping Station.

# EXPERIMENTS ON THE NEWTON WATER AND TREATMENTS FOR THE CONTROL OF CORROSION.

BY F. WELLINGTON GILCREAS.*

[*Read January 10, 1934.*]

The water supply of the city of Newton, Mass., is obtained from ground-water sources. The collecting system, consists of two large dug wells and a wooden conduit laid in the ground water, and with a number of driven wells discharging into it.

*Effect of Infiltration Basins on Ground-water Quality.* A preliminary study of the sources and quality of this supply indicated that certain of the sources were at times of unsatisfactory quality. These were abandoned, the resulting reduction in the quantity of water making it necessary to develop other sources of supply or methods of increasing the yield of the existing sources. Plans were made to raise the ground-water yield by the construction of infiltration or charging basins which would be filled with water from the nearby Charles River. Other papers in this Journal describe the construction and operation of these basins, as well as the increased yields of the various sources of supply resulting from the infiltration process. Because of the poor quality of the Charles River water, it was considered advisable to study the effect of the effluent from the infiltration basins on the quality of the ground water before developing the infiltration plan completely. For this purpose a number of test wells were located at various points around the basins. These were 2½-in. driven wells 50 ft. in depth. Samples were drawn from these test wells by means of an ordinary pitcher pump, the well being pumped to waste for some time before samples were collected to assure a representative sample of the ground water.

Studies of these test wells and also of the dug wells from which the supply is obtained, were continued for several years after the basins were constructed. When the basins were first filled, samples were collected from all sampling stations at frequent intervals, the sampling periods being extended as time went on. The results of these many analyses indicate that the natural soil was most efficient as a filtering medium, removing the color, bacteria and other unsatisfactory constituents of the river water very satisfactorily.

The results of the analyses of samples from the test well nearest to Basin No. 1, namely test well No. 8–28, may be considered representative of the results obtained at all the sampling points during this study. Figure 1 indicates the changes in the critical constituents of the ground water during the months of the years 1928–1929 when Basin No. 1 was in use. During

*Chemist, Weston and Sampson, Consulting Engineers, Boston, Mass.

the winter months, the basin was not in use and no samples from the test wells were collected; hence the gap in the curves. Samples were collected from this well before the basin was filled, the broken line indicating the amounts of the various constituents present in the ground water before infiltration started. The interesting features of this study are the rapid increase in dissolved oxygen and the corresponding decrease in the carbon dioxide content of the ground water shortly after the basin was filled. In

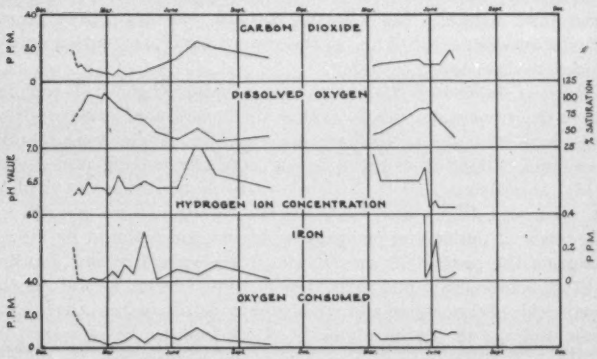



FIG. 1—CHARACTER OF WATER DRAWN FROM TEST WELL NO. 8-28 IN INFILTRATION STUDIES AT NEWTON.

fact, the amounts of these two gases in the ground water were very nearly the same as in the river water, presumably indicating a rapid passage of water from the basin through the gravel soil to the test well. Yet the amount of organic matter in the ground water, as shown by the oxygen consumed values, remained low. During the entire period of the study, the color of the ground water was zero, while that of the river water averaged 60 p.p.m. Bacteriologically, the water from the test well was nearly sterile, the total numbers of bacteria being low and gas-forming bacteria always absent, although the water pumped to the basins contained relatively large numbers of bacteria with gas-forming bacteria and *Bact. coli* present in practically all 10-c.c. portions tested. As the sides and bottom of the basin sealed up with silt, etc. from the river water, with a corresponding decrease in the rate of filtration, the dissolved oxygen and carbon dioxide values gradually changed to values nearer those of the ground water originally. However, the flow of the well continued to be abundant. At times the elevation of the water rose to a point 4 ft. above the surface of the ground. The amount of organic matter continued very low and bacteriologically the water was of excellent quality during the entire period studied. Conditions

in this well were representative of the other test wells except that the influence of infiltration was felt less and after longer periods of time in the wells at greater distance from the basin.

To determine, if possible, how far from the basin, water unsatisfactorily filtered could be found, another series of test wells was driven. The well previously referred to (No. 8–28) was about 150 ft. from the nearest edge of Basin No. 1, and of course at a lower elevation. On a direct line to Basin No. 1, test well No. 8–28B was driven at a point 100 ft., and No. 8–28A at a point 50 ft. from the basin, both being at about the same elevation as test well No. 8–28. These were also 2½-in. wells and driven to a depth of 50 ft. A study of the results, given in Table 1, shows that the gravel soil was filtering the river water satisfactorily; even at a distance of only 50 ft. from the wall of the infiltration basin. Practically all of the objectionable constituents were removed, the color of the water in this well being zero. Bacteria were not completely removed at a distance of 50 ft., although gas-forming bacteria were continuously absent in this well; but in 100 ft. bacterial removal was satisfactory.

At points nearer the basin, the dissolved oxygen became more nearly the same as that of the river water, absorption by the soil being less complete. From these studies it seemed reasonable to assume that infiltration basins located 100 ft. or more from a source of ground-water supply, and with a coarse gravel soil of the type in the Newton Water Department Reservation, would increase the yield of ground water without any deleterious effect on the quality of the ground water.

As additional infiltration basins were built to increase the yield of the wells and conduit that supply the city, the study of the effect upon the ground water and the general supply of such infiltration was continued. The results were about the same in all cases as those shown in test well No. 8–28. The yield of supply well No. 2 was nearly doubled by means of infiltration, but the only change in the character of the water was a lowering of the carbon dioxide value and a corresponding increase in the dissolved oxygen value. When the basins were not in use, the dissolved oxygen and carbon dioxide gradually returned to their original values. With the basins built along the line of the wooden conduit serving to increase the ground water yield in that location, very little effect upon the character of the water found in the conduit could be detected, although close check of the quality of the conduit water was maintained for several years. The yield increased greatly, and the only change detectable was a slight but decided increase in the temperature of the water. The dissolved oxygen and carbon dioxide content of the water changed but little during periods of infiltration.

*Corrosion Studies.* The process of infiltration had provided a sufficient supply of water of low color and excellent appearance and of a satisfactory bacteriological quality. However, the amounts of dissolved oxygen and carbon dioxide had not been changed appreciably and were still such as to cause serious action of the water upon service pipes. Complaints of dirty

water, stained plumbing fixtures, and short life of service pipes, particularly brass pipes, continued to be received. To determine more exactly the effect of the Newton water supply upon various types of service pipes, and

TABLE 1.— INFILTRATION STUDIES, NEWTON WATER DEPARTMENT.
Unless otherwise stated, results of analyses are expressed in parts per million.

| | Test Well No. 8–28 | Test Well No. 8–28B | Test Well No. 8–28A | Charles River |
|---|---|---|---|---|
| Distance from Basin—ft. | 150. | 100. | 50. | .... |
| Turbidity | 0. | 0. | 1.5 | 3. |
| Color | 0. | 5. | 0. | 70. |
| Chlorides | 5.5 | 6.5 | 5.5 | 6.0 |
| Oxygen Consumed | 0.35 | 0.85 | 0.4 | 6.8 |
| Alkalinity | 14.4 | 16.0 | 16.0 | 14.0 |
| pH Value | 6.4 | 6.4 | 6.3 | 6.7 |
| Iron | 0.04 | 1.6 | 0.03 | 0.5 |
| Carbon Dioxide | 5.2 | 7.0 | 6.0 | 6.0 |
| Dissolved Oxygen — per cent saturation | 95.0 | 66.4 | 89.7 | 94.4 |
| Bacteria — 37°C. — 24 hr. | 3. | 7. | 196. | 165. |
| Bacteria — 20°C. — 48 hr. | 3. | 7. | 500. | 138. |
| Gas Forming Bacteria in 5 10-cc. samples | negative | negative | negative | 4 positive |

also to accumulate data upon which to base possible methods of treatment of the supply, a series of experiments was planned and carried on for a period of about one year.

In these experiments, the pipes used were wrought iron, galvanized iron and brass (60–40) pipes and copper tubing, 50-ft. lengths of regular service pipe size being used in each experiment. Four separate experiments with each type of pipe were planned, as follows:

(1) Untreated water.
(2) Regular water supply treated with soda ash to give a pH value of about 8.0.
(3) Aërated water.
(4) Aërated water treated with soda ash to give a pH value of about 8.0.

In order to simulate as nearly as possible the conditions actually obtaining in the average house, it was decided to pass through each experimental pipe 200 gal. of water per day, that being about the average volume of water used per domestic taker in Newton. For ordinary domestic use, the water is run at a rapid rate for a few minutes, then allowed to stand for varying periods in the pipe. As it was not possible to duplicate these conditions exactly, the experiments were planned to run for 12 hours each day, the 200 gal. flowing at an even rate through each section of pipe during that period. For the remaining 12 hours of the day, the flow was shut off

and the pipes allowed to stand full. This permitted the collection of samples representative of conditions of standing and ordinary use. Sampling taps were installed at suitable points in the pipe, and the pipes were slightly elevated to permit them to become filled and remain free of air pockets during the periods of standing. At first meters were installed in each line to measure the amount of water passing through each pipe, with ordinary valves to regulate the flow. Because of the slow rate of flow the meters would not register accurately, tended to impede the flow and were later removed. Also the valves were very unsatisfactory for regulating

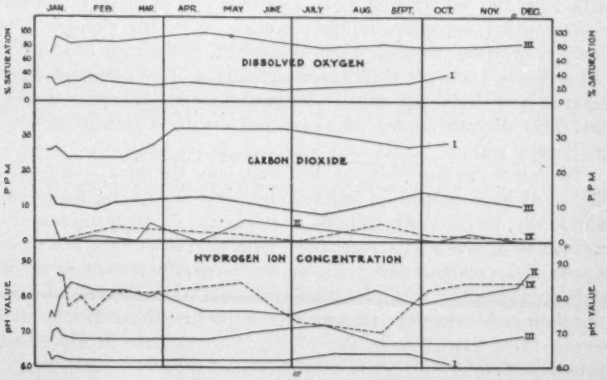



FIG. 2—CHARACTER OF WATER IN EXPERIMENTS ON THE CORROSION OF SERVICE PIPES.

Experiment I.—Untreated water.
Experiment II.—Raw water treated with soda ash (pH 8.2).
Experiment III.—Aërated water.
Experiment IV.—Aërated water treated with soda ash (pH 8.2).

such low flows. For the results of these experiments to be comparable, it was necessary that there should be a uniform flow of water through each pipe, and that the operation of the experimental plant should be constant. In order to maintain a uniform rate of flow through the pipes, Mr. W. S. Burke of the pumping-station staff designed and made orifice disks that could be fitted into the discharge ends of the pipes. These of course had to be different as the size of the orifice depended upon the pressure of the water, which varied considerably among the four experiments. The soda ash was fed into the water by gravity, using constant head tanks and similar orifice disks to keep the flow constant. These ingenious devices kept the flows constant and thereby permitted regular and constant treatment of the water. Aëration was accomplished by spraying through a per-

forated cap into a tank, from which the aërated water flowed by gravity to the proper grid of pipes.

Mr. Burke's faithful attention to the operation of the plant and his care in collecting the samples did much to insure the accuracy of the results.

The controlling factors in the action of water upon metal are the dissolved oxygen, the amount of carbon dioxide present and the pH value which is a function of the concentration of carbon dioxide. In these experiments, then, it was necessary to control these factors or to know their value at all times. Fig. 2 shows the variation in these substances during the year covered by the experiments. The supply being a ground water with a nearly constant temperature, seasonal variations in oxygen and carbon dioxide content are slight. Infiltration made very little change in these values, as previously stated. Thus the oxygen and carbon dioxide values in Experiment I are practically constant during the experimental period. Insofar as possible the pH value of the treated water was kept at a constant point. This diagram shows the variations in these factors during the experimental period.

To determine the effect of the water on the pipes, samples were collected under conditions of ordinary use, that is with the water flowing continuously, and under conditions of standing. These samples were then examined to determine the amount of metal dissolved from the pipes. In the case of the wrought-iron pipe, the iron naturally present in the water was determined and a correction made. Samples were collected at intervals of one, four and seven days, then weekly for the first month and at monthly intervals after that. The results of the four experiments are shown in Figures 3 to 6.

*Experiment I: Untreated Water as Supplied to the City.* Under conditions of use, there was a decided action on the wrought iron pipe at first, but this dropped off after a few weeks, so that but little metal was removed by the flowing water. The action was much more pronounced with the standing samples, but this also decreased as a protective coating of ferric oxide was built up on the walls of the pipe. These results are in accord with experience with the action of corrosive waters on iron pipes. Probably the condition here is similar to that existing in the distribution mains in the city. Occasionally in the experimental unit portions of the deposited ferric oxide would slough off, a condition that also occurs at times in the distribution system, accounting in part for the trouble encountered with dirty water.

With the galvanized iron pipe, action of the flowing water was slight, but under conditions of standing, the solution of large amounts of zinc continued throughout the experiment, although with some irregularities that are hard to explain. With the brass pipe, solution of the zinc under conditions of standing continued with little change throughout the experiment. The flowing water had but little effect. The interesting feature in the experiment is the increased removal of zinc after several months' use.

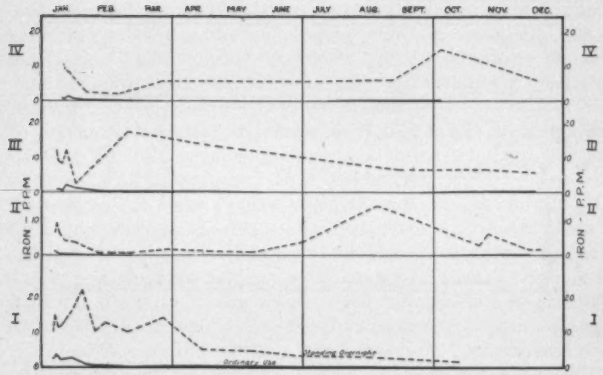



FIG. 3—CORROSION OF WROUGHT IRON PIPE INDICATED BY SOLUTION OF IRON.

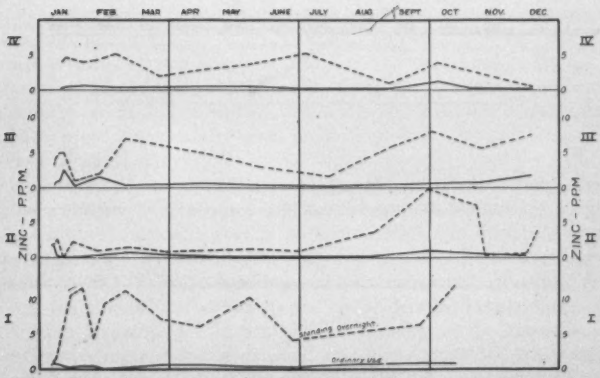



FIG. 4—CORROSION OF GALVANIZED IRON PIPE INDICATED BY SOLUTION OF ZINC.

Experiment I.—Untreated water.
Experiment II.—Raw water treated with soda ash (pH 8.2).
Experiment III.—Aërated water.
Experiment IV.—Aërated water treated with soda ash (pH 8.2).

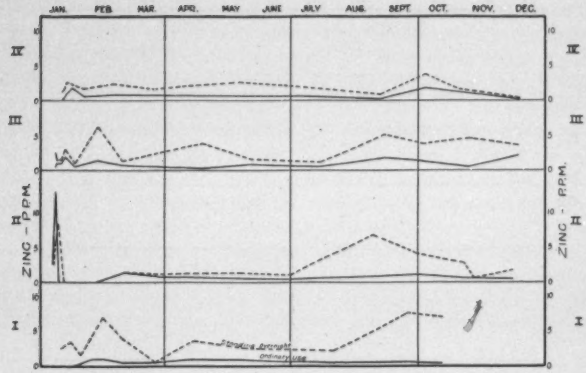



FIG. 5—CORROSION OF BRASS PIPE INDICATED BY SOLUTION OF ZINC.

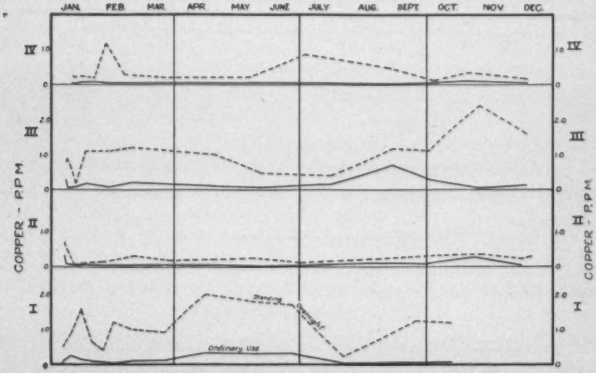



FIG. 6—CORROSION OF COPPER TUBING INDICATED BY SOLUTION OF COPPER.

Experiment I.—Untreated water.
Experiment II.—Raw water treated with soda ash (pH 8.2).
Experiment III.—Aërated water.
Experiment IV.—Aërated water treated with soda ash (pH 8.2).

These results seem to be quite in accord with the general experience with brass pipe in the city and offer some explanation of the short life of brass in most houses in Newton. With the copper tubing, there was also extensive and continued solution of the metal under standing conditions, with appreciable action under flowing conditions. These results were also quite in accord with general experience in the city, and explain the green stains on plumbing fixtures where copper pipe was used.

As previously explained, Experiments II, III and IV were conducted to determine the most satisfactory treatment to prevent the action noted in Experiment I on the various types of pipe metals.

*Experiment II: Water Treated with Soda Ash.* In Experiment II, the regular supply was treated with soda ash to give a pH value of about 8.0. Soda ash forms no protective coating in the pipe but by increasing the pH value acts to decrease the velocity of the chemical action of the oxygen in the water on the pipe and by reducing the concentration of the carbon dioxide reduces the solvent action of that substance upon zinc and copper. The results of this experiment show just that action. Corrosion of the iron pipe was reduced under conditions both of standing and use with the exception of a high value in August, when due possibly to temperature changes deposited iron sloughed off, as often happens in practice. Except for a brief period toward the end of the experiment the galvanized pipe was protected by treatment. With the brass pipe, the treated water dissolved substantial quantities of zinc at the start of the experiment. But this solvent action decreased very quickly, and action on the metal was slight under conditions of standing and flow, except for a brief period at the latter end of the experiment. There seems to be no explanation for this sudden increase in the amount of zinc dissolved. With the copper tubing, treatment provided especially good protection, only very small quantities of copper being dissolved.

*Experiment III: Aërated Water.* In Experiment III, the carbon dioxide and the resulting hydrogen ion concentration were reduced by aëration which, however, increased greatly the concentration of dissolved oxygen. As would be expected with higher concentration of oxygen, the action of the water in the iron pipe was much more pronounced especially under standing conditions. The action on the metal decreased more slowly with time than in Experiment I, indicating less tendency for the deposition of a protective coating of ferric hydroxide. The lower value of carbon dioxide reduced slightly the action of the water on the galvanized pipe, less zinc being dissolved than in Experiment I.

The lower concentration of carbon dioxide resulting from aëration reduced slightly the solvent action of the water for the zinc and copper of the brass and copper pipes. However, a concentration of 10 p.p.m. of carbon dioxide with the increased concentration of oxygen seemed to be sufficient to cause nearly as much action as with the un-aërated water with 25 p.p.m. of carbon dioxide. Results obtained in other investigations with

Newton water would indicate that with concentrations of carbon dioxide exceeding 6 to 7 p.p.m. action on copper with resulting stains on plumbing fixtures might be expected.

*Experiment IV: Aërated Water Treated with Soda Ash.* In Experiment IV, aërated water was treated with soda ash to give the same pH value as in Experiment II, namely about 8.0. As would be anticipated the treatment reduced the action of the water on the iron pipe slightly over that in Experiment III. The reduction in the concentration of carbon dioxide accompanying the increased pH value decreased the action of the water on the other pipes. However, perhaps because of the increased oxygen concentration, protection was not quite equal to that in Experiment II.

These experiments demonstrated that the Newton water supply as received at the station has a decided effect upon the metals constituting the ordinary types of service pipe. Protection of these pipes could be secured by increasing the pH value of the water by the use of soda ash. Reduction of the carbon dioxide content by aëration gave no protection; in fact the action on the iron pipe was increased by the greater concentration of oxygen. Aëration followed by an increase of the pH value failed to give as good protection as similar treatment of the un-aërated water, where the concentration of dissolved oxygen was low.

Because of the relatively short time covered by the experiments examination of sections of the pipes removed after the conclusion of the experiments gave but little information in addition to that obtained by the analyses of the samples of water. The iron pipes showed the presence of a deposit of ferric oxide. The galvanized pipe, especially in Experiment I, showed the result of the solvent action of the water upon the zinc. The copper and brass pipes gave little visual sign of corrosion.

*Use of Lime.* As stated before, soda ash produces no protective coating as a result of its reaction with the carbon dioxide present in the water. Lime, on the other hand, does react with carbon dioxide to precipitate a coating of calcium carbonate on the walls of the pipe which acts as a barrier to prevent further action of the water on the metal. To insure the insolubility of the calcium carbonate, however, pH values higher than 8.0 must be maintained. Addition of lime causes substantial increase in the hardness or soap-consuming power of the water. While the hardness normally present in the water supply at Newton (about 35 p.p.m.) is not high, it is enough greater than that of Boston Metropolitan water to be the cause of some complaint by citizens. In order to avoid increase in the hardness the experiments were conducted using soda ash instead of lime. While the cost of lime treatment would be much less than that of soda ash, the additional cost of soap used by the people would be much larger than the saving in the cost of chemicals. The matter of treating the aërated water with lime was also studied, but it was found that the cost of aëration would be greater than the saving in the cost of chemicals.

Furthermore, the increased concentration of oxygen that would result

from aëration was undesirable, in view of its action on the iron pipe in the experimental work. The higher pH value that would be necessary, if lime was used, in order to insure insolubility of the calcium carbonate coating was about what would cause precipitation of manganese, especially with the higher concentrations of oxygen following aëration. Since the Newton water contains appreciable quantities of manganese, the possibility of trouble with precipitated manganese was to be avoided.

*Treatment Adopted.* In view of these facts and on the basis of the results of the experimental work, it was decided to treat the supply with soda ash to reduce the aggressive action of the water toward metals. It was planned to so treat the water as to maintain the pH value at a point no higher than 8.0, and no lower than 7.6. The upper limit would not cause the precipitation of dissolved manganese, while pH values less than 7.6 would not adequately protect brass and copper. It was also feared that pH values higher than 8.4 might disturb deposits already existing in the mains, with a resulting period of dirty water.

In December 1931, treatment of the supply was started. In order to run no risk of disturbing deposits in the supply mains by too sudden change in the reaction of the water, the pH value was increased very gradually. At first only enough soda ash was introduced to increase the pH value from 6.2, the normal value for the water, to 6.4. This value was maintained for about four weeks. Sampling stations were established in various parts of the city on flowing mains, on dead ends and at the extreme ends of the system to check by analyses the effect of the treatment on the quality of the

TABLE 2.—EFFECT OF TREATMENT WITH SODA ASH, NEWTON WATER DEPARTMENT. Unless otherwise stated, results of analyses are given in parts per million.

| | Pumping Station. | | Supply Yard. |
|---|---|---|---|
| | Untreated | Treated. | |
| Turbidity | 0. | 0. | 0. |
| Color | 2. | 5. | 5. |
| Alkalinity | 26.0 | 74.0 | 72.0 |
| Hardness | 29.9 | 29.9 | 31.2 |
| pH Value | 6.2 | 7.8 | 7.6 |
| Iron | 0.08 | 0.10 | 0.08 |
| Carbon Dioxide | 25.0 | 4.0 | 4.1 |
| Dissolved Oxygen — | | | |
| Per cent saturation | 33.8 | .... | .... |

water. The pH value was then increased slowly by increments of 0.2 pH to the maximum of 7.8 over a period of six months. Samples were collected from each of the sampling stations just before each increase in the dosage of soda ash. In this way a complete check was kept on the effect of the treatment. No trouble was encountered and no complaints of dirty water were received during the period of establishing the treatment, indicating

that the increase in the alkalinity of the water did not disturb deposits already existing in the mains. When the pH value increased to a point above 7.2 complaints of green stains due to the action of the water on copper ceased. In several instances the Water Department received comments to the effect that these stains had ceased and asking why. Treatment of the supply at the pH value decided upon has continued since May 1932, with uniformly good results. Complaints of dirty water, except on dead ends, have decreased markedly. Complaints of green stains due to corrosion of copper have entirely ceased. Of course treatment has not been carried on long enough for all complaints of the collapse of brass pipe to cease. However, it is anticipated that the life of brass service pipe in Newton will be much extended from now on.

Table 2 gives typical analyses of the water at the pumping station before treatment, after treatment with soda ash, and from the tap at the Water Department Supply Yard in Newtonville, the latter representing the character of the water as taken from the distribution system. As treated at present, the carbon dioxide is reduced from 25–30 p.p.m. to 4.0 p.p.m.; the pH value is increased from 6.2 to 7.8. To do this requires the addition of approximately 400 lb. of soda ash per million gallons. With soda ash costing 1.25 cents per pound, this is equivalent to a cost of $5.00 per million gallons of water pumped. During the course of a year, this amounts to about $10 000. However, the improved character of the water and the reduction in its corrosive character compensate for the expenditure.

# PROCEEDINGS.

## DECEMBER MEETING.

STATLER HOTEL, BOSTON, MASS.

Wednesday, December 13, 1933.

Vice-President Howard M. King in the Chair.

THE CHAIRMAN. Gentlemen, at the last meeting of this ASSOCIATION Sir Alexander Houston, a noted English engineer, was made an honorary member of this ASSOCIATION. He has since passed away, and I ask you to rise as a mark of respect.

Secretary GIFFORD. At the Executive Committee meeting this morning Mr. J. Arthur Jackson of Portland, Maine, was elected a member, and Mr. M. N. Baker of New York was reinstated.

I have a report from the Committee on Revision of the Summary of Statistics, which I will read:

BOSTON, December 13, 1933

*Executive Committee, New England Water Works Association.*

*Gentlemen:* Your committee on revision of present form of "Summary of Statistics" as adopted by the ASSOCIATION in 1902, presents the accompanying report showing the proposed revised form.

We desire to acknowledge the help that we have received from the members in compiling this form and recommend that it be set up and copies made available for those who may desire them.

We also recommend that final vote on adoption by the Association be postponed until the next regular meeting, after due notice has been given in the regular calendar.

Respectfully submitted,

(Signed) STEPHEN H. TAYLOR
HERVEY A. HANSCOM
SAMUEL E. KILLAM,
*Chairman.*

A paper "Rigid Service Connections to Main in Preference to Goosenecks," was read by Michael J. Herlihy, Foreman, Newton Water Department, Newton, Mass. Messrs. Roger W. Esty, Henry T. Gidley, David A. Heffernan, Nelson Boardman, Hervey A. Hanscom, Frank S. Brainard, Edmund C. Sanderson, and John S. Caldwell took part in the discussion.

A paper "Water Works Practice at Taunton, Mass.," was read by Arthur C. King, Superintendent and Clerk, Taunton Water Works, Taunton, Mass. Mr. Roger W. Esty discussed the paper.

A paper "Results of a Water Waste Survey in Lexington, Mass.," was read by Albert A. Ross, Superintendent, Water and Sewer Department, Lexington, Mass. The discussion was participated in by Messrs. Henry T. Gidley, Patrick Gear, Richard H. Ellis, and David A. Heffernan.

The following members took part in a discussion of the N.R.A. and C.W.A. programs as applied to Water Works: Frank A. Gifford, Harry F. Beal, Roger W. Esty, Edmund C. Sanderson, Albert A. Ross, Patrick Gear, Donald C. Calderwood and Henry T. Gidley.

[*Adjourned.*]

## JANUARY MEETING.

HOTEL KENMORE, BOSTON, MASS.

Wednesday, January 10, 1934.

President E. Sherman Chase in the Chair.

Secretary GIFFORD. At the meeting of the Executive Committee this morning the following were elected members of the Association.

Lorenzo B. Fortin, Water Commissioner, Greenfield, Mass.; Alfred A. Lamarine, Superintendent Water Works, Wayland, Mass.

A paper "A Resumé of Changes in Practice and Recent Improvements in the Newton Water Department," was read by Richard H. Ellis, Water Commissioner, Newton, Mass.

A paper "Reconstruction of the Pumping Station and the Development of the Source of Supply at Newton, Mass.," was read by George A. Sampson, Consulting Engineer, Weston and Sampson, Consulting Engineers, Boston, Mass.

A paper "The Boiler Plant at the Needham Street Pumping Station," was read by David Eames, Consulting Mechanical Engineer, Boston, Mass.

A paper "Experiments on the Newton Water and Treatments for the Control of Corrosion," was read by Wellington Gilcreas, Chemist, Weston and Sampson, Consulting Engineers, Boston, Mass.

A short discussion of the papers was participated in by David A. Heffernan, Warren A. Gentner, and Robert Spurr Weston.

## FEBRUARY MEETING

HOTEL KENMORE, BOSTON, MASS.

Wednesday, February 14, 1934.

President E. Sherman Chase in the Chair.

Secretary GIFFORD. At the Executive Committee meeting this morning William J. McCarthy, Foreman Water Department, Newton, Mass., was elected to membership.

The PRESIDENT.

I have been asked to call to the attention of the ASSOCIATION House Bill No. 693 which reads as follows:

Chapter ninety-one of the General Laws is hereby amended by adding at the end thereof the following new section:

Section 60. It shall be lawful to swim or boat, or except as otherwise provided in sections twenty-seven, thirty-seven, thirty-eight, thirty-nine, fifty-four, and sixty of chapter one hundred and thirty-one to fish in any lawful manner at any lawful time, in any of the fresh waters of this Commonwealth, other than artificial reservoirs; provided that in so doing no trespass is committed and no pollution dangerous to public health in fact results. Any rule, regulation or order of any public board or officer, or any city or town ordinance, contrary to this section, shall be null and void.

STEPHEN H. TAYLOR. I would like to present the following resolution:

WHEREAS the enactment of House Bill 693, now before the Legislature of Massachusetts, would greatly increase the difficulty of protecting many of the public water supplies of the State against dangerous pollution, and might even make it impossible to prevent acts causing serious hazard of pollution, but where it might be difficult or impossible to prove that "polution dangerous to the public health, in fact, resulted," therefore

BE IT RESOLVED that the New England Water Works Association, in regular meeting assembled, February 14, 1934, notify the Legislative Committee on Water Supply of its opposition to the passage of this or any similar legislation.

(The question was put and the resolution unanimously adopted by a rising vote.)

SAMUEL E. KILLAM presented the outline of the new form for waterworks statistics for discussion.

A paper "The Boston Metropolitan Water Supply Extension," was read by Karl R. Kennison, Designing Engineer, Metropolitan District Water Supply Commission, Boston. The paper was illustrated by stereopticon slides and moving pictures.

Written discussions were submitted by Frank E. Winsor, Robert Spurr Weston, and Francis H. Kingsbury, the latter representing Arthur D. Weston, Chief Engineer, Massachusetts Department of Public Health.

(*Adjourned*)

## ALBERT LIVINGSTONE SAWYER.

This Association mourns the passing of Albert Livingstone Sawyer, an active member for thirty-four years, and Treasurer from September 30, 1924, until his death.

Mr. Sawyer was born in Haverhill, Mass. on July 27, 1864, the son of Harris and Abby Knapp (Livingston) Sawyer, and died, quite suddenly, in the house in which he was born, on September 25, 1933, after several months of ill health.

Mr. Sawyer graduated from the Haverhill High School in 1882 and in 1892 when the city of Haverhill took over the water works he became an inspector and later the Registrar and Clerk of the Board, which positions he held the rest of his life.

Water works administration was made his life study and in 1916 he was awarded the Dexter Brackett Memorial Medal of this Association for the most meritorious paper presented during the year, the subject being "Some Advantages of a Classified Cash Book." He was an assistant assessor for several years and a member of the School Committee from 1904 to 1909, when the commission form of government was established.

Mr. Sawyer was an active member of the Trinity Episcopal Church, and for twelve years was Superintendent of the Sunday School. He also served as vestryman, treasurer and clerk, and for years was a delegate to the diocesan convention of the church. He had been a licensed lay reader since 1893, and as such had read the service in various churches of the diocese during the summer months, and was also treasurer of the Merrimack Branch of the Church School Union. He was greatly interested in the work of the Haverhill Boys Club and was Treasurer from 1909 until his resignation in 1932, accepting no compensation for this service. He was a member of the Episcopalian Club of Massachusetts, and the Haverhill Historical Society, of which he was Treasurer from 1924 to his death.

His loss will be keenly felt in every circle in which he had a part.

Herbert C. Crowell
John Carroll Chase.

## SIR ALEXANDER HOUSTON.

Sir Alexander Cruikshank Houston, Director of Water Examination, Metropolitan Water Board since 1905, died at Hampstead on October 29, 1933, at the age of 68. He was to have retired at the end of the year.

The son of Surgeon-General John Houston, he was educated at Merchiston Castle School, Edinburgh, and Edinburgh University, where he took his medical degrees in 1889. He was awarded the Gunning Victoria Jubilee Alison Prize in public health and medical jurisprudence in 1892 and graduated B.Sc., and D.Sc. He worked for the Local Government Board on lead poisoning due to moorland water supplies from 1893 to 1905, and on various other subjects connected with public health from 1897 to 1905.

For the London County Council he was engaged on sewage disposal experiments at Crossness and Barking in 1898–1900, and later on the bacteriology of watercress, milk and other foods. He was bacteriologist to the Royal Commission on Sewage Disposal, 1899–1905, and was one of the experts engaged in the arbitration proceedings arising out of the formation of the Metropolitan Water Board, and in the Belfast Health Enquiry, 1907. In 1907 he was appointed British representative on the International Commission of three experts to enquire into the quality of the Cairo water supply, and with the late Sir Alexander Binnie held a similar enquiry at Ottawa in 1913.

In addition to numerous reports Sir Alexander was the author of "Studies in Water Supply," 1914; "Rivers as Sources of Water Supply," 1917; and "Rural Water Supplies and their Purification," 1918. He had been an Honorary Member of the Institution of Water Engineers (England) since 1923 and of the New England Water Works Association since 1929.

His pioneer work in the chlorination of the Lincoln (England) water supply in 1904 led the way to the world-wide adoption of this method of disinfection for water supplies. His annual reports as Director of Water Examination of the Metropolitan Water Board, contain a vast amount of valuable routine and research data relating to the quality of water supply.

He was a man of broad culture as attested by the charm of the descriptive portions of his annual reports. To meet him was a delight and the friendliness and kindliness of his manner was such as to endear him to those with whom he came in contact. By his death the New England Water Works Association has lost one of its most distinguished members, and the world its foremost authority on water quality.

E. SHERMAN CHASE.

Most of the biographical material has been furnished by A. T. Hobbs, M. Inst. C. E. Sec'y. Inst. of Water Engineers, of England.

## FLOYD A. NAGLER.

Floyd A. Nagler, member of this Association since 1919, died on November 10, 1933, following an emergency operation. Professor Nagler had been a member of the faculty of the University of Iowa since 1920, first as Assistant Professor of Mechanics and Hydraulics and then as Professor of Hydraulic Engineering. In 1931, due largely to his energetic work, the Iowa Institute of Hydraulic Research was created by the State Board of Education, and Professor Nagler became the first Director of the Institute.

His technical and scientific contributions number more than 50 significant articles dealing chiefly with his specialty—hydraulic engineering and hydrology. Three of his papers won for him prizes offered by the American Society of Civil Engineers.

In addition to membership in the New England Water Works Association he was a member of the American Society of Civil Engineers, Society for the Promotion of Engineering Education, American Association for the Advancement of Science, American Meteorological Society, American Water Works Association, Iowa Engineering Society and American Geophysical Union.

E. SHERMAN CHASE.

Data furnished by F. T. Mavis, Assoc. Director, Iowa Institute of Hydraulic Research.

# INDEX OF ADVERTISERS.


| | Page |
|---|---|
| Atlas Mineral Products Co. | xxvi |
| Barbour, Frank A. | ii |
| Barrows, H. K. | ii |
| Bingham & Taylor | v |
| Blair & Marchant | iii |
| Builders Iron Foundry | ix |
| Caldwell, Geo. A., Co. | xv |
| Cement Lined Pipe Co. | xxvii |
| Conard, William R. | ii |
| Copper and Brass Research Association | viii |
| Crosby, Irving B. | ii |
| Donaldson Iron Co. | xxvi |
| Eddy Valve Co. | xvii |
| Edson Manufacturing Co. | x |
| Ellsworth, Samuel M. | iii |
| Fairbanks-Morse & Co. | xxi |
| Fay, Spofford & Thorndike | ii |
| Ferullo, G., Co. | iii |
| Ford Meter Box Co. | xix |
| Fuller & Everett | ii |
| General Pipe Cleaning Co. | xix |
| Goodnough, X. Henry, Inc. | ii |
| Golden-Anderson Valve Specialty Co. | xxiv |
| Hayes Pump and Machinery Co. | xxxiii |
| Hays Mfg. Co. | xx |
| Hersey Mfg. Co. | iv |
| Hughes, Edward F. | iii |
| Hydraulic Development Co. | xii |
| Kennedy Valve Mfg. Co. | xvi |
| Lead Lined Iron Pipe Co. | xxvi |
| Leadite Co. | Back cover |
| Lock Joint Pipe Co. | Facing front cover |
| Ludlow Valve Mfg. Co. | xxvii |
| Main, M. B. | xxv |
| Massur, F. A., & Co. | xix |
| Metcalf & Eddy | ii |
| National-Boston Lead Co. | xviii |
| National Meter Co. | xiv |
| National Water Main Cleaning Co. | xxxiii |
| Neptune Meter Co. | vi |
| New England Water Works Association | xxvi |
| Pirnie, Malcolm | iii |
| Pierce-Perry Co. | xxvii |
| Pitometer Company | iii |
| Pittsburgh Equitable Meter Co. | vii |
| Rensselaer Valve Co. | xxv |
| Ross, Anthony & Son | iii |
| Ross Valve Mfg. Co. | xxxiii |
| Smith, The A. P., Mfg. Co. | xix |
| Sumner & Dunbar | xxvii |
| Thorpe, Lewis D. | iii |
| Turbine Equipment Co. | xxii |
| Union Water Meter Co. | xi |
| U. S. Cast Iron Pipe and Foundry Co. | Facing back cover |
| Wallace & Tiernan | xxiii |
| Warren Foundry and Pipe Co. | x |
| Weston & Sampson | ii |
| Whitman & Howard | ii |
| Wood, R. D., & Co. | xxviii |
| Worthington-Gamon Meter Co. | xiii |


(Classified index on page xxxii)

## ENGINEERS' SECTION


### H. K. BARROWS

M. Am. Soc. C. E.

*Consulting Hydraulic Engineer*

Water Power, Water Supply, Sewerage, Drainage. Investigation Reports, Valuations, Designs, Supervision of Construction

BOSTON, MASS. 6 BEACON ST.

### WHITMAN & HOWARD

*Civil Engineers*

(Est. 1869. Inc. 1924.)

Investigations, Designs, Estimates, Reports and Supervision in all Water Works and Sewerage Problems.

89 Broad Street, Boston, Mass.

### FAY, SPOFFORD & THORNDIKE

Consulting Engineers

Investigations Reports Designs
Engineering Supervision Valuations

Port Developments Industrial Plants
Bridges Buildings Foundations

Water and Sewerage Works

44 SCHOOL STREET BOSTON

### METCALF & EDDY

ENGINEERS

Harrison P. Eddy — John P. Wentworth
Charles W. Sherman — Harrison P. Eddy, Jr.
Almon L. Fales — Arthur L. Shaw
Frank A. Marston — E. Sherman Chase

Water, Sewage, Drainage, Refuse and Industrial Wastes Problems
Laboratory Valuations
STATLER BUILDING BOSTON

### X. HENRY GOODNOUGH, Inc.

*Engineers*

X. Henry Goodnough
Bayard F. Snow Fred O. Stevens

Water Supply, Drainage, Sewerage, Sewage Disposal, River Improvement, Disposal of Municipal and Industrial Wastes.

14 BEACON STREET, BOSTON, MASS.

### WESTON & SAMPSON

*Consulting Engineers*

Robert Spurr Weston George A. Sampson

Water Supply and Sewerage
Chemical and Bacteriological Laboratory

14 BEACON ST. - BOSTON, MASS.

### FULLER & EVERETT

(FORMERLY HAZEN & EVERETT)

*Civil Engineers*

W. E. FULLER C. M. EVERETT

WATER WORKS
Design Construction Operation
Valuations Rates

22 East 40th Street New York City

### FRANK A. BARBOUR

*Consulting Engineer*

Water Supply, Water Purification, Sewerage and Sewage Disposal.

Tremont Building, Boston, Mass.

### IRVING B. CROSBY

*Consulting Geologist*

Investigations of Dam and Reservoir Sites, Groundwater Supplies, and Sand and Gravel Deposits for cities and industries. Soil Testing Laboratory.

6 Beacon St., Boston, Mass.

**LEWIS D. THORPE**
**Civil and Sanitary Engineer**
Water Works, Sewerage and Sewage Disposal
Supervision of Construction and Operation
**6 Beacon Street**
**BOSTON, MASS.**

**MALCOLM PIRNIE**
***ENGINEER***
Water Supply, Treatment, Sewerage
Reports, Plans, Estimates,
Supervision and Operation,
Valuation and Rates.
**25 W. 43rd Street** **New York, N. Y.**

**THE PITOMETER COMPANY**
**ENGINEERS**
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
**50 Church Street** **New York City**

**BLAIR & MARCHANT, Inc.**
*Civil Engineers*
Clarence M. Blair Orson H. Marchant
**Water Supply, Sewerage, Drainage**
Reports Valuations Rates
Design Specifications Construction
100 Crown Street, New Haven, Conn.

**Samuel M. Ellsworth**
Mem. Am. Soc. C. E.
*Consulting Engineer*
**Water Supply and Sewerage**
Investigations, Reports and Designs
Supervision of Construction and Operation
12 Pearl Street, Boston

CONTRACTORS

**G. FERULLO COMPANY**
**General Contractors**
Specializing in Water Works
**31 NORTH SQUARE**
**BOSTON, MASS.**
Telephone, Richmond 1200

**EDWARD F. HUGHES**
***Water Works Contractor***
Public and Private Water Supply
*Artesian and Driven Wells*
Foundation Borings
53 State St. Room 1102 Boston

**Water Works Contractors and Supply Houses**
Your card may be inserted in this space for $12 per year

**ANTHONY ROSS & SON**
**Public Works Contractors**
(Since 1890)
Trailer Service Trench Excavators
Office and Yard
97 Bedford Street - Lexington, Mass.
Tel. Lex. 1032

# FOUR BOYS CAN'T DO A MAN'S WORK

Nor can four 3-inch disc meters handle large and small flows as efficiently as the ONE 6-inch Hersey Compound Meter which replaces them.

While you are getting 1260 gallons per minute as the safe maximum capacity of a battery of four 3-inch meters—the Hersey 6-inch Compound Meter delivers 2300 gallons per minute.

It gives you a free flow with very low loss of head. Accuracy on large and small flows. No noticeable drop in registration accuracy at the vital "cross-over" point.

We make both kinds of meters. No disc meters excel ours in accuracy and capacity. But we never hedge on which to use for large flow measurements. We recommend the Hersey Compound Meter every time.

A meter of the finest mechanical design and construction—the best money-earner you can put in your department.

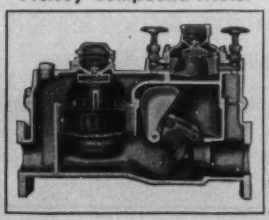
## HERSEY COMPOUND METER WINS

**1.** Patented Counter-balanced Lever Valve exclusive with Hersey eliminates cross-over "flutter." Action is positive and instantaneous. Drop in registration accuracy only fraction of what is allowed by standard specifications.

**2.** This is the ONLY Compound Meter in which the controlling valve has met every requirement of the Fire Underwriters and has their approval for use in fire service meters. No loss of pressure when called on for heavy draft. Cannot be clogged in any way to prevent opening or closing.

**3.** Two small valves make it possible to shut off the by-pass meter so that it can be cleaned or tested without closing down the water supply.

Hersey Compound Meter



HERSEY MANUFACTURING CO., South Boston, Mass

Branch Offices: New York, 290 Broadway; Portland, Ore., 1231 N. W. Hoyt St.; Philadelphia, 314 Commercial Trust Bldg.; Atlanta, 510 Haas-Howell Bldg.; Dallas, 402 Praetorian Bldg.; Chicago, 844 Rush St.; San Francisco, 553 Howard St.; Los Angeles, 450 East Third St.

HERSEY
WATER METERS

STANDARDIZE ON GOOD METERS

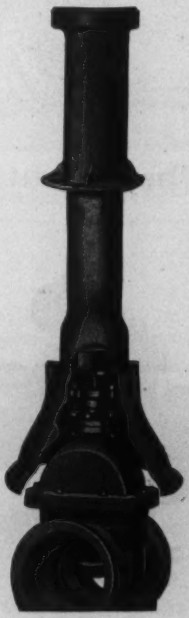
BINGHAM & TAYLOR'S Sliding Type Service and Valve Boxes are meeting with the approval of many New England Waterworks officials.

The cuts shown are our two and three piece sliding type adjustable valve boxes.

**The flange on the bottom of the top section can be located any distance from the top.**

We carry a complete stock on hand at all times.

Wire, phone or write us when you are in a hurry for a shipment.



ESTABLISHED 1849

B & T

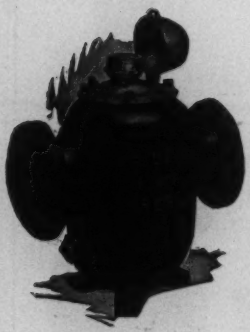
**Bingham and Taylor Corporation**

MANUFACTURERS

575-601 Howard Street . . Buffalo, N. Y.

# They're out to get your Meter Money

## *YOU HAVEN'T GOT A CHANCE!*



TRIDENT CREST METER

You haven't got a chance of real water meter economy or of adequate water revenue when you buy cheap water meters—meters you'll eventually have to turn over to "Old Man Scrapheap." But when you buy Trident or Lambert Water Meters you buy once and for all. No scrapping . . . after long years of sustained accuracy in service at minimum maintenance cost you simply insert new interchangeable parts and your original meters are good as new. How many meters did you scrap in the last 2 years? None . . . if you are using Tridents or Lamberts! No wonder MORE than 6 million of these rugged meters have been made and sold the world over. A complete line of Water Meters, in types specifically designed for every condition of service. Send for catalogs to the Neptune Meter Company (Thomson Meter Corp.,) 50 East 42nd St., New York City . . . or Neptune Meter Co., Ltd., Toronto, Ont., Canada.

NRA WE DO OUR PART

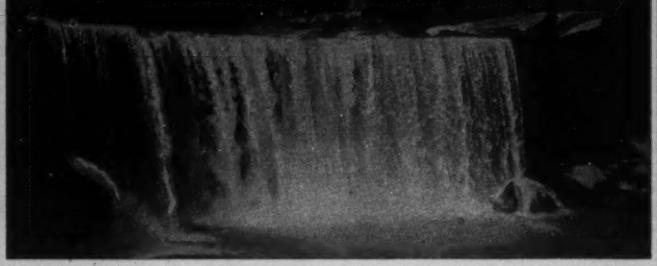
*"Cash Registers of the Water Works Field"*

# TRIDENT

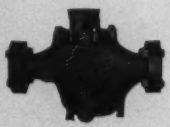
## and LAMBERT WATER METERS

*"The Last Water Meters You Will Ever Have to Buy"*

# *In Corbin, Kentucky!*



*Cumberland Falls—Kentucky's Niagara of the South, located only a few miles from Corbin, is the Southland's most beautiful waterfall.*



The fastest growing city in Kentucky is Corbin. Located in the southeastern corner, 1,076 feet above sea level, within a few minutes of either Tennessee or Virginia, this city offers many advantages to its established, as well as prospective, manufacturers.

The officials of the City of Corbin have shown their aggressiveness in that a universal metering program is being carried on at this time, using Pittsburgh Meters. They state that, "After installing 50% of the meters ordered from Pittsburgh Equitable, the water consumption in the city was reduced from 20,000,000 gallons to 16,000,000 gallons per month. It is figured on a conservative basis, that, when the metering program is completed, the City of Corbin will save $5,000.00 per year on operating expenses, truly a worth while saving."

**PITTSBURGH EQUITABLE METER CO.**
**MERCO NORDSTROM VALVE CO.**

*Main Offices Pittsburgh, Pa. — Branch Offices and Warehouses in Principal Cities*

2 REASONS FOR SPECIFYING

Copper SERVICE Tubing

Service pipe suffers damage from two sides at once—if it's made of metal that can rust. Water attacks it from the *inside*. Soil corrosion attacks it from the *outside*. Sooner or later the pipe must be replaced. A costly business, as the records show!

But, if the service pipe is made of copper, this won't happen. Copper can't rust on the *inside*. And it resists soil corrosion on the *outside*.

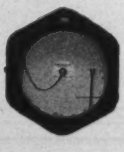
Flexible copper tubing can be bent to any angle without the necessity of making joints. It's more economical to install. And—once in, it stays in. It does not clog up with rust. It does not discolor water. It is lasting, efficient, economical.

That is why up-to-date regulations and codes specify copper service tubing. In this connection the experience of our research engineers, covering many cities and all possible soil and water conditions, is available to you. Write us:

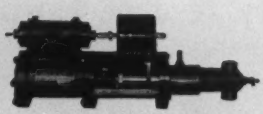
COPPER & BRASS RESEARCH ASSOCIATION, 25 Broadway, New York City

## FOR THE WATER WORKS OF NEW ENGLAND

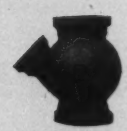
THE HERSCHEL STANDARD VENTURI METER TUBE AND TYPE M REGISTER-INDICATOR-RECORDER
for Main Pipe lines.



THE CHRONOFLO
ELECTRIC FLUID METER
for long distance transmission
of flow rates, reservoir levels and
elevated tank pressures.



THE TRET-O-UNIT
MECHANICAL
PROPORTIONER
for automatically feeding
chemical solutions
to water lines
under pressure.



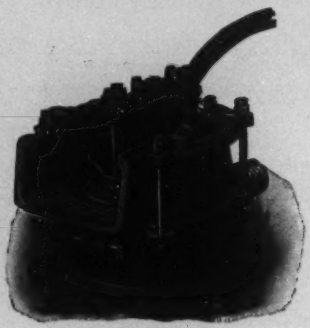
GLOBE SPECIAL
FITTINGS

## BUILDERS IRON FOUNDRY

*"Builders of the Venturi since 1891"*

9 Codding Street VENTURI Providence, R. I.

# EDSON
## PUMPS and ACCESSORIES



Hand Pumps – Power Pumps
Truck or Trailer Mounted
Edson Special Suction Hose
Red Seal Diaphragms
Strainers, Adapters, etc.

*Distributors for*
*Pollard Pipe Line Equipment*
*Redi-Prime Pumps*
*Rodax and Portable Light*

## THE EDSON CORPORATION
49 D Street, Tel. SOUth Boston 3041 South Boston
New York: 142 Ashland Place, Brooklyn

# Warren Foundry & Pipe Corp.
ALSO
**Warren Pipe Co. of Mass., Inc.**

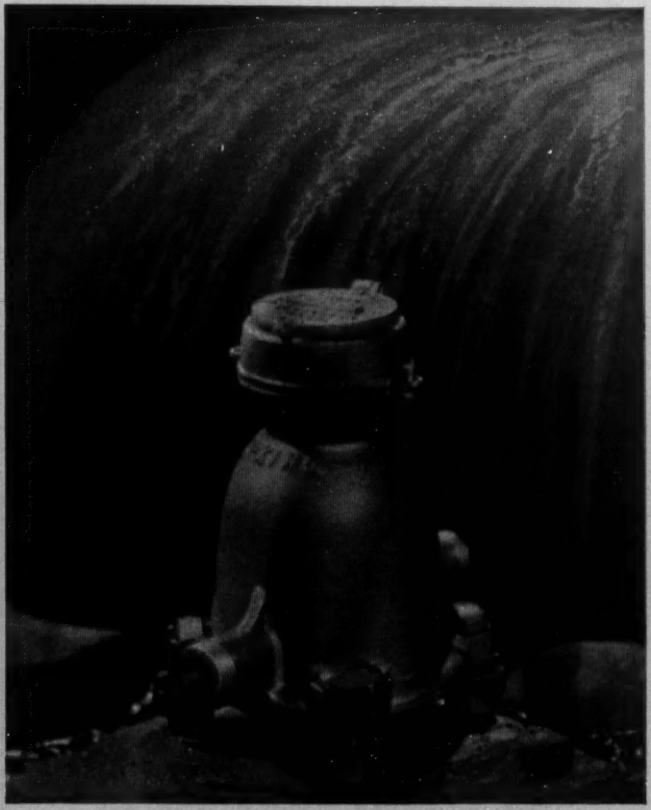
*SALES OFFICES*
11 BROADWAY, NEW YORK
75 FEDERAL STREET, BOSTON, MASS.

*Manufacturers of*
# CAST IRON PIPE

*Flanged Pipe* *Flexible Joint Pipe*
*Bell and Spigot Pipe*
*Special Castings* *Short Body B. & S. Specials*
*Warren (WF) Spun Centrifugally Cast Iron Pipe*

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.
*Large Stock Enables Us to Make Prompt Shipments*

# UNION



**For 65 years Union meters and allied products have sustained an unrivaled reputation for serviceability.**

**Union Water Meter Co., Worcester, Mass.**

**Incorporated 1868**

# "Never a Failure in Over 22 Years!"

WE like to talk about saving in material and labor—the strong, tight, flexible joints made with Hydro-Tite—the thousands of miles of pipe jointed with it.

More important, perhaps, is the fact that with hundreds of users—each laying pipe under different conditions—not a single one has reported a Hydro-Tite failure.

We make it very easy for you to change over to Hydro-Tite. Our Data Book outlines a novel proposition. Write for it.

*A Symbol of Quality*

*A Dependable Self-Caulking Joint Compound*

**HYDRO-TITE**

**HYDRAULIC DEVELOPMENT CORPORATION**

*Main Sales Office:* 50 Church Street, New York, N. Y.
*General Offices and Works:* West Medford Station, Boston, Mass.

WORTHINGTON

WATCH DOG

# Built for the future
## *on a foundation of* EXPERIENCE

AS a builder of water meters, this organization draws upon an uninterrupted experience of seventy-five years. *Result* . . . accuracy and durability to meet present and future requirements.

More than 3,200,000 Worthington and Watch Dog Meters are in use today.

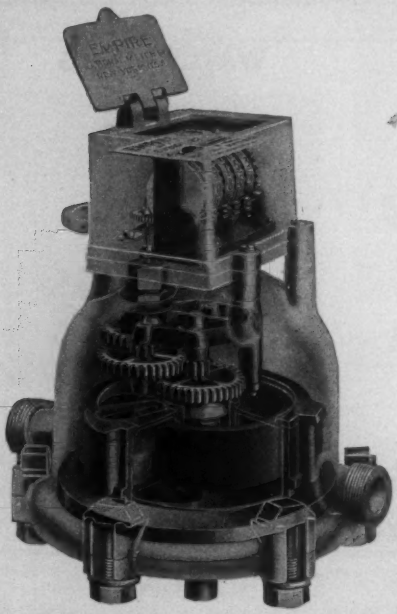
WORTHINGTON-GAMON METER COMPANY
GENERAL OFFICES: HARRISON, NEW JERSEY
*District Sales Offices and Representatives:*

| | | | | | | |
|---|---|---|---|---|---|---|
| ATLANTA | CINCINNATI | DENVER | HOUSTON | NEW ORLEANS | PITTSBURGH | SAN FRANCISCO |
| BOSTON | CLEVELAND | DETROIT | KANSAS CITY | NEW YORK | ST. LOUIS | SEATTLE |
| BUFFALO | DALLAS | EL PASO | LOS ANGELES | PHILADELPHIA | ST. PAUL | TULSA |
| CHICAGO | | | | | | WASHINGTON |

*Branch Offices or Representatives in Principal Cities of Foreign Countries*

**WORTHINGTON-GAMON**

M-89A




NATIONAL
EMPIRE · NASH · CROWN · GEM
EMPIRE-COMPOUND · PREMIER
METERS
NATIONAL METER COMPANY

NRA
MEMBER
U.S.
WE DO OUR PART

## For Maximum Revenue

from metering, use Empire Meters. They may cost a little more at the outset, but in the long run they cost much less than ordinary meters.

Empire Meters have led the field since 1884, in accuracy, durability, and economy. They are right in principle and in construction. The superiority of Empire Meters has been established by service records over a period of half a century.

Save money with Empire Meters.

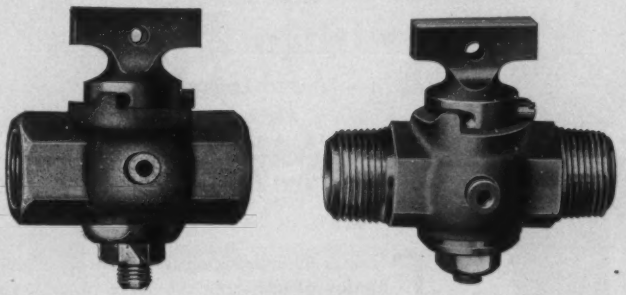
## NATIONAL METER COMPANY

**4209 First Avenue, Brooklyn, New York**

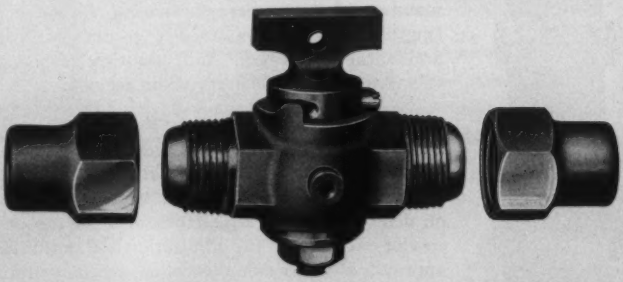
BOSTON CHICAGO LOS ANGELES SAN FRANCISCO

## ALL COCKS HAVE SOLID PLUG

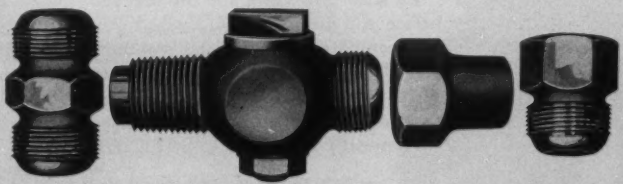
**Full Size Waterway—Easy Turning—Tested at 200 lbs.**



TEE HEAD NEWPORT STOP AND WASTE COCKS



TEE HEAD NEWPORT STOP AND WASTE COCK
With Double Copper Tubing Connections



Cocks for ¾" Copper Tubing have 1" I. P. Male Threads and Cocks for 1" Copper Tubing have 1¼" I. P. Male Threads. This allows our cocks to be used with regular I.P. fittings when necessary.

**GEORGE A. CALDWELL CO.**
MATTAPAN SQUARE BOSTON, MASS.

# 80 cities within 2 years

*have installed Kennedy SAFETOP Fire Hydrants*

THESE 80 municipalities—located in every section of the country—have made a good start toward reducing their fire hydrant maintenance expenses, eliminating fatalities and lengthy interruptions to fire protection due to accidental breakages, and assuring thoroughly effective, dependable fire hydrant service.

The exclusive features of the Kennedy SAFETOP Fire Hydrant which provide these important benefits have been thoroughly established. Wherever this unique hydrant has been tried out—whether on demonstration test, accidental breakage or fire service—it has won the admiration and enthusiastic approval of water department superintendents and engineers.

Be sure to investigate the Kennedy SAFETOP before you purchase new hydrants for additions or replacements. You can readily obtain the benefits of SAFETOP construction for your existing hydrants. Write for complete details on Adapters, by which hydrants of any other design can be quickly and economically converted to SAFETOPS.

**The Kennedy Valve Mfg. Co., Elmira, N. Y.**

# KENNEDY SAFETOP FIRE HYDRANT

REG. U.S. PAT. OFF.

Type of Eddy Hydrant Popularly Used

*More Than Sixty Years of Experience Goes Into All*

# EDDY

## Hydrants and Valves

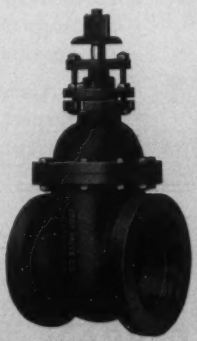
BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

## The Eddy Valve, Too

Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.



### Other Eddy Products

The Eddy line of water-works products also includes horizontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

WRITE FOR CATALOGUE

## EDDY VALVE COMPANY

WATERFORD, N. Y., U. S. A.

# National-Boston Lead Co.

**800 Albany St., Boston**

Agents for

## The Celebrated "ULCO"

# LEAD WOOL

**(Every Atom Pure Lead)**

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

**Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.**

**HIGHEST QUALITY SOFT BRANDS**

## PIG LEAD

## CLEAN PIPE LINES

having high coefficients deliver more water and give better fire protection than corroded mains.

High coefficients mean greater delivery in gravity mains and lower power costs in pumping mains.

**GENERAL PIPE CLEANING COMPANY**

Commercial Trust Bldg. Philadelphia, Pa.

## F. A. MAZZUR CO., INC.

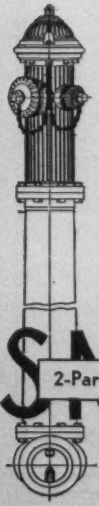
ENGINEERS AND CONTRACTORS

WATER PUMPING INSTALLATIONS
SEWAGE PUMPING INSTALLATIONS
PUMPING STATIONS
POWER PLANT EQUIPMENT
SUCTION AND FORCE MAINS
TRANSMISSION LINES
SUBMERGED SUCTION LINES
DRIVEN WELL SYSTEMS

*Emergency Work a Specialty*

All Types of Pumps in Stock for Rental

141 MILK STREET Phone HANcock 4570 BOSTON, MASS.



**Minimum Trouble and Expense When Breaks Come**

THE Smith Two-Part Standpipe Hydrant was designed to make the expense as small as possible when there is a break as the result, for instance, of careless auto truck driving.

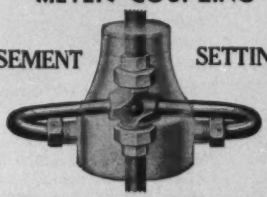
The upper section will always break first. It can easily be renewed. And of course there can be no leakage of water because the main valve is of the compression type.

SMITH

2-Part Standpipe Hydrant

**THE A. P. SMITH MFG. COMPANY**
**EAST ORANGE, N. J.**

*The*
## COPPERHORN
**METER COUPLING**
for BASEMENT SETTINGS

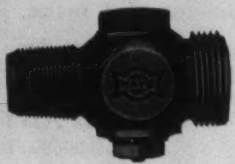


- 1 **Meter set horizontally** at desired height in vertical pipe without ells, nipples or couplings.
- 2 **All copper water way.** No rusting or corrosion. Freezing will not burst it.
- 3 **Smooth oversize tubing** and sweeping bends, maximum flow.
- 4 **Meter changes** do not disturb piping whether the meter is in or out.
- 5 **On new services** it serves as a spacer to connect in the piping.
- 6 **Provides a permanent** electrical ground connection.

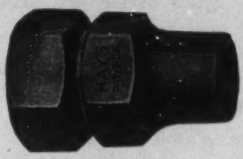
May We Give You Further Information About the Copperhorn?

**The FORD METER BOX COMPANY**
Wabash, Indiana

# The Hays Copper Plumbing Method

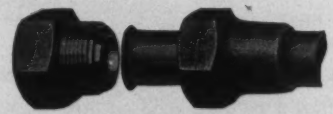


Regular Corporation Stop



Adapter

In making an installation with Hays Copper Service Fittings the regular Corporation Stops can be used in conjunction with the adapter. It is not necessary to procure new mandrels, as the Corporation Stops are inserted with the regular mandrels, in the usual manner, after which the adapter is attached.



Open View of Adapter

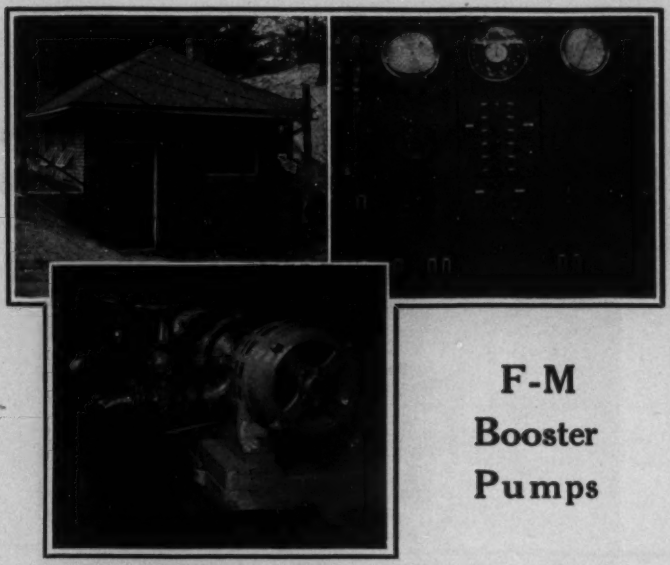
These adapters are made with Female Thread for Increased I. P., Water Works Standard or Lead Flange.

To use standard Corporation Stops with Increased I. P. or Water Works Standard Thread, and where a direct connection of the Corporation Stop and Copper Pipe is desired, the above stop has been designed. (See cut above for sectional view of joint.) These stops permit a Hays 90° seal with the use of regular male mandrels.

*Write for complete details of*

**The Hays Copper Plumbing Method for Water Works and House Plumbing**

## Hays Manufacturing Co. Erie, Pa.



F-M
Booster
Pumps

# At SOUTH HADLEY, MASS.

Shown above are the exterior of the South Hadley Water Works Pumping Station, the two F-M Motor Driven Centrifugal Pumps installed in the station and the control equipment. The station is located at one extreme end of the town and takes water from a small reservoir under a positive head of approximately 12 or 15 feet and pumps it through the main section of the town to a standpipe at the other end. Both pumps and motors are of ball bearing design, which construction was selected because of the desirable feature of lubrication. The bearings require attention only once a year.

FAIRBANKS, MORSE & CO.

178 Atlantic Avenue, Boston, Mass.

# FAIRBANKS-MORSE

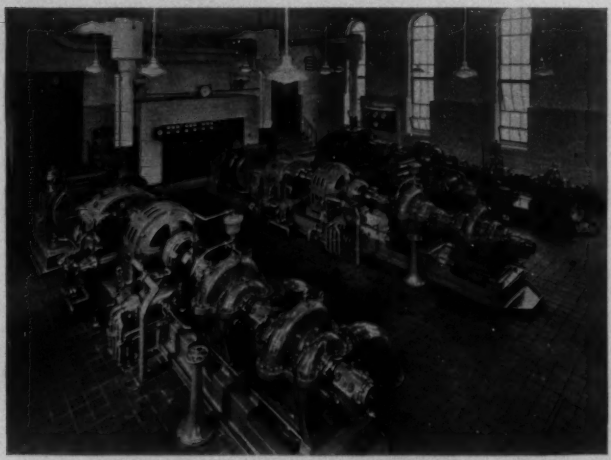
PUMPS · DIESEL ENGINES · MOTORS

# DE LAVAL

## Geared Turbine Driven

# PUMPS and GENERATORS

## The Most Modern and Efficient Pumping Station in New England



CITY OF NEWTON, MASSACHUSETTS

R. H. ELLIS, Water Commissioner WESTON & SAMPSON, Consulting Engineers

**The three units are designed for 4¼, 6 and 8 M. G. D. against 272, 295 and 340 feet pumping head respectively with steam at 230 pounds gage, 125 degrees superheat 29 inches vacuum.**

**Acceptance tests showed each unit exceeded its guarantees by a liberal margin.**

## TURBINE EQUIPMENT COMPANY

OF NEW ENGLAND

80 Federal Street Phone LIB erty 5993-4 Boston, Mass.

New England Representative for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, N. J.

"THE ONLY SAFE WATER IS A STERILIZED WATER"

# "WATCH THE WHEELS GO 'ROUND"

Watching the wheels go 'round used to be a fascinating boyhood pastime. For most of us it's now an obligation and any sign that the wheels are not turning steadily means "get busy".

It's easy to "watch the wheels go 'round" in W&T Vacuum Chlorinators because the working parts are under the glass bell jar, always in plain sight. Don't play "hide and seek" with trouble—know what's happening by installing W&T Visible Control Vacuum Chlorinators on your plant.

Technical Publication No. 38—a copy free—tells all about them.

## WALLACE & TIERNAN CO.

INCORPORATED

*Manufacturers of Chlorine and Ammonia Control Apparatus*

Newark, New Jersey — Branches in Principal Cities

Main Factory—Belleville, New Jersey

SA-51

# GOLDEN-ANDERSON

## Patent Automatic Cushioned Controlling Altitude Valves

We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves":
1st —Automatically, by water.
2nd—By Electricity, if desired.
3rd —By Hand

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. No valves of fixtures inside or outside.

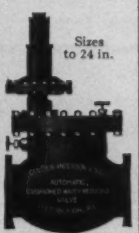
New Haven Water Co. New Haven, Conn. now using 2–24" 1–16" 2–12" 1–10" ALTITUDE VALVES

*Remember!*

"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

**30** of these ALTITUDE VALVES sizes, 6" to 24" serving the City of Los Angeles, Calf., now.

### GOLDEN-ANDERSON
**Pat. Automatic Cushioned Water Pressure Regulating Valves**



Sizes to 24 in.

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required — No attention necessary.
5. Positively no hammering or sticking.

### GOLDEN-ANDERSON
**Patent Automatic Cushioned Controlling Float Valves**

They carry a constant water level in feed water heaters, Tanks and Reservoir by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.

### GOLDEN-ANDERSON
**Pat. Automatic Cushioned Water Float Valves**

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle — Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.

Angle or Globe

Sizes to 24 in.

### GOLDEN-ANDERSON
**Patent Automatic Double Cushioned Check Valve**

Sizes to 24 in. Angle or Globe

Automatically prevents reverse flow of pressure. Perfectly cushioned to prevent shock or hammer. Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping. Arranged so that quick or slow operating may be obtained.

**Golden-Anderson Valve Specialty Co., 1325 Fulton Bldg., Pittsburgh, Pa.**

***Main's Hotcoating*** for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

*Also*

***Main's Coverall Salt Air Paint,*** for the outside of standpipes and water tanks, guaranteed for four years.

**M. B. MAIN** **Box 189, Somers Point, N. J.**

The "COREY" Hydrant

# Why you should use GENUINE COREY HYDRANTS

Water to Nozzles quicker than other Hydrants.

Standpipe can be removed and replaced without shutting off water in main.

Ease of operation insured by knuckle joint principle.

Only 13 turns to completely open or completely close, but full flow with only 4 turns.

Nozzles screwed in — not leaded.

Can be lengthened without shutting off water.

Will not flood if broken.

Positive Drip — cannot freeze.

Standpipe can be revolved quarter turns — Nozzles always in right direction.

Ask for our Catalog "G"

**CHARLES L. BROWN,**

*New England Sales Manager, Lock Box 2, Northboro, Mass.*

**RENSSELAER VALVE COMPANY**

**TROY, N. Y.**

# DONALDSON IRON CO.

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND...

Special Castings for Water and Gas.
Also Flange Pipe and Fittings.

Boston Office:
CHARLES F. GLAVIN
24 Milk Street

EMAUS,
LEHIGH COUNTY, PA.

## New England Water Works Association

***Specifications and Meter Rate Sheets***

Standard Specifications for Cast-iron Pipe and Special Castings, per copy, $0.25

Meter Rate Sheets: Single sheet ..... 0.05
100 sheets, in orange ..... 2.50
100 sheets, in black ..... 2.25

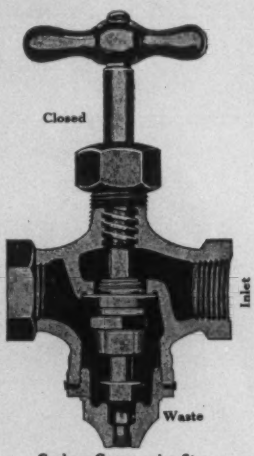
USE
**MINERALEAD**
*For Jointing Bell and Spigot Water Mains*

Easy handling, ingot form — Impervious to moisture — Absolute uniformity — Easy melting — Rapid pouring — No caulking — Less initial leakage — Bell holes unnecessary — A saving in cost of material and labor.

SEND FOR CATALOG

**The Atlas Mineral Products Company**
OF PENNSYLVANIA
MERTZTOWN, PENNSYLVANIA

*New England Sales Representative*
H. R. PRESCOTT
110 North Parkway
Worcester, Massachusetts




Gorham Compression Stop and Waste Cock

Copper Flanged Corporation Stop

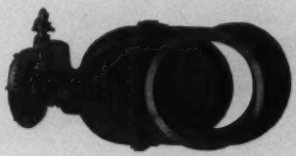
S. & G. Water Works Brass Goods
S & D Heavy Pattern Slip Type Service Boxes
Byers' Wrought Iron Pipe
Annaconda Brass Pipe and Copper Service Tubing
Service, Roadway and Valve Boxes
Cast Iron Pipe and Fittings

**SUMNER & DUNBAR**
12-18 Pittsburgh St., Boston, Mass.
Telephone, LIBerty 1350

**CEMENT LINED SERVICE PIPE**
With Specially Adapted Lead-lined Fittings
Also Curb Cocks which eliminate Iron to Brass Corrosion both inside and out.
**CEMENT LINED PIPE CO.**
**LYNN, MASS.**

**PIERCE-PERRY CO.**
*Wholesalers of*
Water Works Brass Goods.
Byers Wrought Iron Pipe.
Youngstown Steel Pipe.
Valve and Service Boxes.
**236 Congress St., Boston, Mass.**
Telephone, Hancock 7817-7818.

*FEWER PARTS*



MEAN *Longer* LIFE

Ludlows last longer because they are simple in design. Manganese bronze stems, hard composition seat rings and ground faces on gates and seat rings guarantee continuous reliable performance. You can install Ludlows and know you have the best.

*The* LUDLOW
VALVE MFG. COMPANY
TROY · · · · NEW YORK

# SPECIFY MATHEWS

## FOR P. W. A. AND C. W. A. WORK

Spend wisely now. Your city can borrow easily and buy cheaply. For your fire hydrants, specify Mathews:

1. Mathews Hydrants will serve long after your bonds are liquidated. Many 60-year old Mathews Hydrants are still in use. Hence their initial cost becomes very small.

2. Mathews are inexpensive to maintain. They don't freeze, they are serviced with an oil can, every part is accessible.

3. Mathews Hydrants make traffic accidents unimportant. If broken they don't leak, and can be replaced without digging.

## "SAND-SPUN" PIPE

NO BETTER PIPE THAN "SAND-SPUN" IS MADE. A PRODUCT FUNDAMENTALLY DIFFERENT FROM PIT-CAST PIPE. NO ANNEALING IS NECESSARY—16 ft. lengths furnished in all sizes 4 ins. to 36 ins. inclusive. 20 ft. lengths also furnished in sizes 12 ins. to 30 ins. inclusive . . . We are prepared to ship by water, rail or truck.

R·D·WOOD & CO · 400 CHESTNUT STREET PHILADELPHIA

ESTABLISHED IN 1803

# CLASSIFIED DIRECTORY OF ADVERTISEMENTS.


**AIR COMPRESSORS.** Page
Hayes Pump and Machinery Co. . . . xxxiii

**BOILERS, STEAM.**
Massur, F. A., & Co. . . . xix

**BRASS GOODS.**
(See also Pipe, Brass.)
Caldwell, George A., Co. . . . xv
Cement Lined Pipe Co. . . . xxvii
Copper and Brass Research Association . . . viii
Hays Mfg. Co. . . . xx
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii
The A. P. Smith Mfg. Co. . . . xix
Union Water Meter Co. . . . xi

**CALKING MACHINERY AND TOOLS.**
The A. P. Smith Mfg. Co. . . . xix

**CAST IRON PIPE.** (See Pipe, Cast Iron.)

**CEMENT LINED PIPE.** (See Pipe, Cement Lined.)

**CHEMICAL FEED APPARATUS.**
Wallace and Tiernan Co., Inc. . . . xxiii

**CHLORINATORS.**
Wallace & Tiernan Co., Inc. . . . xxiii

**CLEANING WATER MAINS.**
General Pipe Cleaning Co. . . . xix
National Water Main Cleaning Co. . . . xxxiii

**COCKS, CURB AND CORPORATION.**
Caldwell, George A., Co. . . . xv
Hays Mfg. Co. . . . xx
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii
The A. P. Smith Mfg. Co. . . . xix
Union Water Meter Co. . . . xi

**CONCRETE PIPE.**
(See Pipe, Concrete.)

**CONDENSERS.**
Hayes Pump and Machinery Co. . . . xxxiii
Massur, F. A., & Co. . . . xix

**CONSTRUCTION EQUIPMENT.**
Edson Mfg. Corp. . . . x

**CONTRACTORS.**
Ferullo, G., Co. . . . iii
Hughes, Edward F. . . . iii
National Water Main Cleaning Co. . . . xxxiii

**CURB BOXES.**
Bingham and Taylor . . . v
Caldwell, George A., & Co. . . . xv
Hays Mfg. Co. . . . xx
Sumner & Dunbar . . . xxvii

**CURB AND VALVE BOX FINDERS.**
Caldwell, George A., Co. . . . xv

**DIAPHRAGMS, PUMP.**
Edson Mfg. Corp. . . . x

**ENGINEERS.**
Barbour, Frank A. . . . ii
Barrows, H. K. . . . ii
Blair & Marchant . . . iii
Fay, Spofford & Thorndike . . . ii

## CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*.


**ENGINEERS.—*Continued*** PAGE

Ellsworth Samuel M . . . iii
Fuller & Everett . . . ii
Goodnough, Inc., X. Henry . . . ii
Metcalf & Eddy . . . ii
Pirnie, Malcolm . . . iii
Ross, Anthony & Son . . . iii
Thorpe, Lewis D. . . . iii
Weston & Sampson . . . ii
Whitman & Howard . . . ii

**ENGINES.**
(See Pumps and Pumping Engines.)

**ERECTORS, WATER WORKS AND POWER MACHINERY.**
Hayes Pump and Machinery Co. . . . xxxiii
Massur, F. A., & Co. . . . xix
Turbine Equipment Co. . . . xxii

**FEED WATER HEATERS.**
Hayes Pump and Machinery Co. . . . xxxiii
Massur, F. A., & Co. . . . xix
Ross Valve Mfg. Co. . . . xxxiii

**FILTER RATE CONTROLLERS AND GAGES.**
(See Rate Controllers.)

**FILTERS AND WATER SOFTENING PLANTS.**
Ross Valve Mfg. Co. . . . xxxiii

**FILTRATION PLANT EQUIPMENT.**
Builders Iron Foundry . . . ix
Ross Valve Mfg. Co. . . . xxxiii
Wallace & Tiernan Co., Inc. . . . xxiii

**FLEXIBLE JOINTS.**
U. S. Cast Iron Pipe and Foundry Co. . . . Facing back cover

**FURNACES, ETC.**
Atlas Mineral Products Co. . . . xxvi
The A. P. Smith Mfg. Co. . . . xix
The Leadite Co. . . . Back cover

**GAGES, SURFACE, RESERVOIR AND SPECIAL WATER WORKS.**
Builders Iron Foundry . . . ix

**GATE VALVES.** (See Valves.)

**GEOLOGISTS.**
Crosby, Irving B. . . . ii

**HOSE, SUCTION AND CONDUCTION.**
Edson Mfg. Corp. . . . x

**HYDRANTS, FIRE.**
Eddy Valve Co. . . . xvii
Kennedy Valve Mfg. Co. "Newtype" . . . xvi
Ludlow Valve Mfg. Co. . . . xxvii
Rensselaer Valve Co. "Corey" . . . xxv
Ross Valve Mfg. Co. . . . xxxiii
The A. P. Smith Mfg. Co. . . . xix
Wood, R. D., & Co. . . . xxviii

**LEAD.**
National-Boston Lead Co. . . . xviii

**LEAD PIPE.**
(See Pipe, Lead.)

**LEAD WOOL.**
National-Boston Lead Co. . . . xviii

**LEAK FINDERS.**
Pitometer Co. . . . iii

**LIQUID CHLORINE.**
(See Chlorine, Liquid.)

**METERS, WATER AND OIL.**
Builders Iron Foundry . . . ix
Gamon Meter Co. . . . xiii
Hersey Mfg. Co. . . . iv

## CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).


**METERS** — *Continued* PAGE
National Meter Co. . . . xiv
Neptune Meter Co. . . . vi
Pitometer Co. . . . iii
Pittsburgh Equitable Meter Co. . . . vii
Union Water Meter Co. . . . xi
Worthington-Gamon Meter Co. . . . xiii

**METER COUPLINGS.**
Ford Meter Box Co. . . . xix

**METERS (VENTURI TYPE).**
Builders Iron Foundry . . . xi
National Meter Co. . . . xiv

**METER BOXES.**
Bingham and Taylor . . . v
Ford Meter Box Co. . . . xix

**METER TESTERS.**
Ford Meter Box Co. . . . xix

**OIL ENGINES, DIESEL.**
Fairbanks-Morse & Co. . . . xxi
Hayes Pump and Machinery Co. . . . xxxiii

**PIPE, BRASS.**
Copper and Brass Research Association . . . viii
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii

**PIPE, CAST IRON (AND FITTINGS).**
Builders Iron Foundry . . . ix
Donaldson Iron Co. . . . xxvi
U. S. Cast Iron Pipe and Foundry Co. . . . Facing back cover
Warren Foundry and Pipe Co. . . . x
Wood, R. D., & Co. . . . xxviii

**PIPE, CEMENT LINED.**
Cement Lined Pipe Co. . . . xxvii
Union Water Meter Co. . . . xi

**PIPE, CONCRETE.**
Lock Joint Pipe Co. . . . Facing front cover

**PIPE CUTTING MACHINES.**
The A. P. Smith Mfg. Co. . . . xix

**PIPE JOINTING MATERIAL.**
Atlas Mineral Products Co. . . . xxvi
Hydraulic Development Co. . . . xii
The Leadite Co. . . . Back cover

**PIPE, LEAD.**
National-Boston Lead Co. . . . xviii

**PIPE, WROUGHT IRON AND STEEL.**
Pierce-Perry Co. . . . xxvii
Sumner & Dunbar . . . xxvii

**PITOMETERS.**
Pitometer Co. . . . iii

**PRESSURE REGULATORS.**
Caldwell, George A., Co. . . . xv
Golden-Anderson Valve Specialty Co. . . . xxiv
Ross Valve Mfg. Co. . . . xxxiii
Union Water Meter Co. . . . xi

**PROVERS, WATER.**
Pittsburgh Equitable Meter Co. . . . vii

**PUMPS AND PUMPING ENGINES.**
Edson Manufacturing Corp. . . . x
Fairbanks-Morse & Co. . . . xxi
Hayes Pump and Machinery Co. . . . xxxv
Massur, F. A., Co. . . . xix
Ross Valve Mfg. Co. . . . xxxiii
Turbine Equipment Co. . . . xxii
Wood, R. D., & Co. . . . xxviii

## CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued).*


**RATE CONTROLLERS.** PAGE
Builders Iron Foundry . . . . . ix

**SLEEVES AND VALVES, TAPPING.**
Ludow Valve Mfg. Co. . . . . xxvii
Rensselaer Valve Co. . . . . xxv
The A. P. Smith Mfg. Co. . . . . xix

**SPECIFICATIONS, FORM AND METER RATE SHEETS**
New England Water Works Association . . . . . xxvi

**SULPHATE OF ALUMINA.** (See Alum.)

**SUPPLIES AND TOOLS.**
Caldwell, George A., Co. . . . . xv
Hays Mfg. Co. . . . . xx
Pierce-Perry Co. . . . . xxvii
Sumner & Dunbar . . . . . xxvii
The A. P. Smith Mfg. Co. . . . . xix
The Leadite Co. . . . . Back cover

**TANK PAINT.**
M. B. Main . . . . . xxv

**TAPPING MACHINES.**
Hays Mfg. Co. . . . . xx
The A. P. Smith Mfg. Co. . . . . xix

**TAPPING SLEEVES.** (See Sleeves and Valves, Tapping.)

**VALVE BOXES.**
Bingham and Taylor . . . . . v
Ford Meter Box Co. . . . . xix
Rensselaer Valve Co. . . . . xxv
Wood, R. D., & Co. . . . . xxviii

**VALVE INSERTING MACHINES.**
The A. P. Smith Mfg. Co. . . . . xix

**VALVE SPECIALTIES.**
Golden-Anderson Valve Specialty Co. . . . . xxiv

**VALVES, GATE.**
Eddy Valve Co. . . . . xvii
Kennedy Valve Mfg. Co. . . . . xvi
Ludlow Valve Mfg. Co. . . . . xxvii
Rensselaer Valve Co. . . . . xxv
Ross Valve Mfg. Co. . . . . xxxiii
The A. P. Smith Mfg. Co. . . . . xix
Wood, R. D., & Co. . . . . xxviii

**VALVES, REGULATING.**
Golden-Anderson Valve Specialty Co. . . . . xxiv
Ross Valve Mfg. Co. . . . . xxxiii
Union Water Meter Co. . . . . xi

**WATER WASTE DETECTION.**
Pitometer Co. . . . . iii

**WROUGHT IRON PIPE.** (See Pipe, Wrought Iron and Steel.)

THE STANDARD FOR 50 YEARS

Automatic Pressure Control Valves
Water Works Specialties

Altitude — Pressure Reducing — Surge
Relief and Combination Valves
Portable Fire Hydrants
Hydraulic Booster Pumps

ROSS VALVE MFG. CO., INC. TROY, N.Y.

# Health and Protection First

Water delivered through dirty pipes
may be a MENACE.

Incrusted water pipes mean inefficiency
and loss of Fire Protection.

We Guarantee the Results of Our
Method of Cleaning.

WRITE US.

## National Water Main Cleaning Co.

50 Church Street New York City

# HAYES PUMP AND MACHINERY CO.

101 PEARL ST., BOSTON, MASS.

Pumping Plant Contractors
CENTRIFUGAL, POWER, STEAM PUMPS

STEAM TURBINES
WATER WHEELS

ELECTRIC MOTORS
OIL ENGINES

# *Announcing*
# Super-de Lavaud Pipe

In 1932, we began to produce at our Burlington plant, and later at other plants, a Super-de Lavaud Cast Iron Pipe, centrifugally cast by a new patented process developed in our Research Laboratory. The outstanding feature of this new pipe is an extraordinary increase in impact-resistance. After a year's experience in production and shipments we are now ready to announce that:

**SUPER-DE LAVAUD CAST IRON PIPE, centrifugally cast by our patented improved process, is *shatter-proofed* to the extent that *impact-resistance has been increased more than 100 per cent.* Thus, maximum protection against hazards of handling and transporting has been built into Super-de Lavaud Pipe in order that pipe which is perfect *for service underground* shall remain perfect *from plant to underground.* While the human element in handling pipe is always unpredictable, it now becomes a negligible factor under any but abnormal conditions in transit, unloading and laying.**

The major advantage resulting from the extraordinary increase in the impact-resistance of Super-de Lavaud Pipe is in protection against the hazard of damage in handling and transit but it must be obvious that this pipe will render super-service underground. Super-de Lavaud Pipe establishes a standard of its own exceeding the requirements of the Federal Specifications Board for this product. Send for descriptive booklet.

**UNITED STATES PIPE AND FOUNDRY COMPANY**

GENERAL OFFICES . . . BURLINGTON, N. J.

FOUNDRIES AND SALES OFFICES THROUGHOUT THE UNITED STATES

# The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness. ALL MEMBERS OF THE ASSOCIATION RECEIVE THE JOURNAL IN PART RETURN FOR THEIR ANNUAL DUES; to all others the subscription is four dollars per annum.

---

## TO ADVERTISERS

THE attention of parties dealing in goods used by Water Departments is called to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS and CONTRACTORS in the United States. The paid circulation is **1100** COPIES.

Being filled with original matter of the greatest interest to Water Works officials, it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertisements being inserted solely to help meet the large expense of publication.

### ADVERTISING RATES.

| | |
|---|---|
| One page, one year, four insertions | Eighty Dollars. |
| One-half page, one year, four insertions | Fifty-six Dollars. |
| One-fourth page, one year, four insertions | Thirty-six Dollars. |
| One-twelfth page (card), one year, four insertions | Twelve Dollars. |
| One page, single insertion | Forty Dollars. |
| One-half page, single insertion | Thirty Dollars. |
| One-fourth page, single insertion | Twenty Dollars |

Size of page, 4½ x 7½ net.

A sample copy will be sent on application.

For further information, address,

GORDON M. FAIR, Editor,
112 PIERCE HALL,
HARVARD UNIVERSITY,
CAMBRIDGE, MASS.

The Post Pill Press
SAMUEL USHER
BOSTON, MASSACHUSETTS

# LEADITE

## "Joint it with LEADITE"

—is almost a "by-word" with
waterworks men—everywhere

Not alone in the United States, but in Central and South America—and in a number of foreign countries there are miles-upon-miles of water mains—JOINTED WITH LEADITE.

There are of course many "reasons why" Leadite has been so EXTENSIVELY SPECIFIED AND USED for over a quarter century—but after all is said and done, the chief reason is:

"COMPLETE SATISFACTION," — RESULTING FROM UNVARYING QUALITY,—Efficiency of the joint,—and Economy of installation.

***The pioneer self-caulking material for c. i. pipe.***
***Tested and used for over 30 years.***
***Saves at least 75%***

THE LEADITE COMPANY

Girard Trust Company Bldg. Philadelphia, Pa.

No Caulking